THE NUTRITIOUS DRINK:

a specialized nutrient supplement for adults and adults living with HIV in Malawi

Santiago Rodas-Moya

THE NUTRITIOUS DRINK:

a specialized nutrient supplement for adults and adults living with HIV in Malawi

Santiago Rodas-Moya

Thesis Committee

Promotor

Prof. Dr Kees de Graaf

Professor of Sensory Science and Eating Behaviour

Wageningen University & Research

Co-promotor

Dr Saskia de Pee

Scientific Technical Advisor of the Nutrition Division

United Nations World Food Programme

Other members

Prof. Dr CPGM de Groot, Wageningen University & Research

Dr A.M. Mwangwela, Lilongwe University of Agriculture and Natural Resources (LUANAR), Malawi

Prof. Dr M.W. Bloem, John Hopkins University, Bloomberg School of Public Health, Baltimore, USA

Dr W. Vaessen, Essensor, Ede

This research was conducted under the auspices of the Graduate School VLAG (Advanced studies in Food Technology, Agrobiotechnology, Nutrition and Health Sciences).

The Nutritious Drink:

a specialized nutrient supplement for adults and adults living with HIV in Malawi

Santiago Rodas-Moya

Thesis

submitted in fulfilment of the requirements for the degree of doctor

at Wageningen University

by the authority of the Rector Magnificus,

Prof. Dr A.P.J. Mol,

in the presence of the

Thesis Committee appointed by the Academic Board

to be defended in public

on Tuesday 07 January 2020

at 01:30 p.m. in the Aula

Santiago Rodas-Moya

The Nutritious Drink:
a specialized nutrient supplement
for adults and adults living with HIV in Malawi
186 pages

PhD thesis, Wageningen University, Wageningen, the Netherlands, (2020)
With references, with summary in English

ISBN: 978-94-6395-220-0
DOI: https://doi.org/10.18174/507370

Contents

Summary

INTRODUCTION

Undernutrition is a major problem in the world, affecting vulnerable population groups such as people living with HIV (PLHIV). Ready-to-use-therapeutic-foods or corn-soy-blends [e.g., Super Cereal (SC)] are often used to treat undernutrition among PLHIV. However, their acceptability and compliant use are not optimal.

THESIS AIM

To develop a culturally appropriate food nutrient supplement with sensory properties tailored to the preference, primarily of PLHIV, and potentially of adults from the general population, leading to more optimal micronutrient intake.

METHODS

We conducted two qualitative studies based on Grounded Theory. In-depth interviews with a triangulation of participants and an iterative approach to data collection were used to investigate the factors influencing preferences for food and nutrient supplements among PLHIV. Based on the results of the qualitative research, we developed eight samples of a nutritious drink.

Next, we studied the olfactory and gustatory (chemosensory) function of PLHIV to assess whether they suffer from chemosensory losses that could explain possible differences in preferences for the eight samples of the nutritious drink. We used the Sniffin' Sticks and Taste Strips to assess the olfactory and gustatory function of 100 PLHIV and 100 healthy adults for comparison.

Subsequently, 100 PLHIV and 98 healthy adults evaluated the nutritious drink samples. We used hedonic scales for assessing liking, and CATA (check-all-that-apply) questions to develop a sensory characterization of the nutritious drink samples. Penalty analysis was conducted to identify the drivers of liking and disliking of the samples for subsequent product optimization.

Our last study assessed the acceptability and ad libitum intake of the nutritious drink, RUTF, and SC. Fifty-four PLHIV evaluated the products, monadically on three consecutive days. The three food nutrient supplements were served in isocaloric portions of 1000 kcal each. Participants were instructed to consume the products ad libitum. The participants were also asked to rate their liking and wanting for each product. Time of consumption (ad libitum), the number of bites used to consume the products were also measured, and the eating rate was calculated.

RESULTS

The findings from the qualitative studies indicated that PLHIV preferred a thick beverage slightly sweet and sour as a nutrient supplement. Maheu, a maize-based drink of sweet and sour flavor and a thick, gritty consistency was utilized as a benchmark for the development of the nutritious drink samples for Malawi. The results from the study on olfactory and gustatory function, suggest that PLHIV suffer from olfactory loss. However, their gustatory function was normal.

The findings from the study using CATA questions showed clear and significant differences in the acceptability of the samples, but no significant differences in preferences between PLHIV and healthy adults. The sensory characterization of the samples made by the two groups was also similar. A preference toward sweet, somewhat sour, thick samples with a soft texture and a milky flavor was identified.

The results from the ad libitum intake study showed a significantly higher intake of the nutritious drink (356 g) compared to RUTF (107 g) and SC-porridge (312 g). The average intake of eight essential micronutrients as a percentage of target quantities was 58 % from the nutritious drink, 33 % from RUTF, and 20 % from SC. The average caloric intake from the nutritious drink, RUTF, and SC was 507, 581, and 339 kcal, respectively.

DISCUSSION AND CONCLUSIONS

The combination of qualitative research and advanced techniques from sensory science allowed us to identify a product of high acceptability and to identify directions for tailoring the sensory properties of the product to the preference of the potential consumers. A more substantial weight of food and larger quantities of micronutrients were ingested from the nutritious drink compared to RUTF and SC. The nutritious drink also had a much higher eating rate compared to the semisolid supplements. These findings suggest that nutrient-dense food supplements in liquid form may be more effective than semisolid products (e.g., RUTF and SC) in treating undernutrition among PLHIV and other adults. Future research should focus on testing the efficacy of the nutritious drink in the treatment of undernutrition in comparison to RUTF and SC.

Chapter 1

General introduction

BACKGROUND

Malnutrition in all its forms (undernutrition, micronutrient deficiencies, overweight, and obesity) is a problem in the world. An estimated 2 billion people are obese, 2 billion people suffer from micronutrient deficiencies, 155 million children are stunted, and 50 million children are wasted (Swinburn et al., 2019). Globally, malnutrition affects disproportionally people living in low- and middle-income countries (LMIC) and, in all countries, people living in poverty (Haddad et al., 2018; Swinburn et al., 2019). Among the most vulnerable population groups affected by malnutrition are people living with HIV (PLHIV), particularly those living in food-insecure countries where undernutrition and HIV coexist (Haddad et al., 2018).

In populations affected by food insecurity, access to nutritious foods is restricted. Therefore, nutrient deficiencies are highly prevalent (FAO, 2018). Specialized nutritious foods, such as lipid-based nutrient supplements or fortified-blended foods, are an essential means to support food-insecure PLHIV to ingest meaningful quantities of micronutrients and protein (Saskia De Pee & Richard D Semba, 2010). Yet, the development of specialized nutritious foods has been primarily focused on its nutrient composition, giving little attention to their sensory acceptability. This has resulted in low acceptance of lipid-based nutrient supplements and fortified-blended foods among PLHIV, which has challenged the efficacy of the nutritional therapy (F. Dibari, P. Bahwere, et al., 2012; Mesrach Ayalew Kebede & Jemal Haidar, 2014).

The Sensory acceptability of food, which is culture-specific (Prescott & Bell, 1995; Prescott, Young, O'neill, Yau, & Stevens, 2002; Rozin & Vollmecke, 1986a), is a critical determinant of food consumption (Forde, 2018; Piqueras-Fiszman & Spence, 2015; Rolls, Rowe, & Rolls, 1982). Hence, when developing specialized nutritious foods, studying the consumers' preferences for product categories and their sensory properties is paramount. Moreover, several studies have shown that viscosity (liquid vs. solid), play a key role in the amount of food that people can ingest. Larger volumes of food can be consumed from liquids compared to solid and semisolid foods (de Graaf, 2011, 2012; De Wijk, Zijlstra, Mars, De Graaf, & Prinz, 2008; DiMeglio & Mattes, 2000; Zijlstra, Mars, de Wijk, Westerterp-Plantenga, & de Graaf, 2008). This suggests that beverages could be more effective in treating and preventing undernutrition.

The goal of the research conducted for this thesis was to develop a culturally pertinent food nutrient supplement with sensory properties tailored to the preferences of the potential consumers. We aimed to develop a palatable food nutrient supplement that could lead to hiegher nutrient intake for treating and

preventing undernutrition among PLHIV, and potentially for other adults.

Next, in this chapter, we discuss:

- the burden of food insecurity among PLHIV;
- the synergistic effect of malnutrition and HIV infection on PLHIV's health;
- the role of nutrient supplements in PLHIV's nutrition and health;
- food nutrient supplements commonly used for PLHIV in LMIC;
- the influence of culture in the acceptability of food nutrient supplements;
- the development of the nutritious drink samples;
- sensory perception of food among PLHIV;
- sensory properties of food and food acceptability;
- viscosity, and food intake.

The introduction closes with a presentation of the thesis outline, its objectives, and chapters.

The burden of food insecurity among people living with HIV

Food insecurity is defined as "the lack of access to sufficient amounts of safe and nutritious food for normal growth and development, as well as an active and healthy life." (Pinstrup-Andersen, 2009). Food insecurity is associated with poverty, it is a leading cause of malnutrition, morbidity, and mortality, and it is intertwined with HIV (Nigel Rollins, 2007; Ayele Tiyou, Tefera Belachew, Fisehaye Alemseged, & Sibhatu Biadgilign, 2012). In sub-Saharan Africa, an estimated 33.8 % of the population (~346 million people) is food-insecure (FAO, 2018), and 20 million people are HIV positive (UNAIDS, 2018). In Malawi alone, with a population of approximately 13 million people, about one million are HIV-positive (UNAIDS, 2018), and 52.4% of the population is food insecure (FAO, 2018). Hence, food insecurity and the consequent malnutrition and health-related issues are a public health concern in Malawi and many other sub-Saharan African countries.

Among PLHIV, food insecurity has been associated with a reduced willingness to start antiretroviral therapy (ART) and with a lack of compliance to ART (Martin W Bloem & Randa Saadeh, 2010). This is because, at the start of ART, the side effects may be stronger if the medicines are taken without food and because ART increases the feeling of hunger. Hunger is a strong motive for PLHIV to stop ART (Mesrach Ayalew Kebede & Jemal Haidar, 2014). Furthermore, it has been demonstrated that food insecurity is associated with an increased

behavioral risk for HIV transmission and to a reduced interest in seeking health care (Aranka Anema, Nicholas Vogenthaler, Edward A Frongillo, Suneetha Kadiyala, & Sheri D Weiser, 2009; Nigel Rollins, 2007; Ayele Tiyou et al., 2012). Hence, addressing food insecurity is crucial to improve the living conditions of PLHIV, their nutrition, and health and may contribute to reducing the risk of HIV transmission. Food nutrient supplements are an important means to address food insecurity and hunger among food insecure populations.

The synergistic effect of malnutrition and HIV

HIV and undernutrition have additive effects in the deterioration of the immune function and contribute to increase morbidity and mortality (Saskia De Pee & Richard D Semba, 2010). Undernutrition among PLHIV is caused primarily by insufficient ingestion of food, increased metabolic demand, and malabsorption of nutrients (Saskia De Pee & Richard D Semba, 2010; Christine Wanke, Kotler, & Committee, 2004). The insufficient food intake, in addition to food insecurity, may also be due to health challenges such as anorexia, oral and dental problems, gastrointestinal symptoms (Mangili, Murman, Zampini, Wanke, & Mayer, 2006), and depression (Isaac et al., 2008). Some of these symptoms may appear as side effects of ART (Faintuch, Soeters, & Osmo, 2006). The increased metabolic demand is primarily due to an altered metabolism caused by HIV infection. When untreated or in an advanced HIV stage, the metabolic demand may also be increased by opportunistic infections, malignancies, and hormonal deficiencies (thyroid, adrenal, or gonadal) (Aranka Anema et al., 2009; Saskia De Pee & Richard D Semba, 2010; Faintuch et al., 2006; Christine Wanke et al., 2004). The leading causes of malabsorption are diarrhea and helminth infection (Aranka Anema et al., 2009; Mangili et al., 2006). The damage of the gut epithelium by pathogens may also cause malabsorption in advanced HIV stages. The insufficient ingestion of food, the increased metabolic demand, and malabsorption result in weight loss, which is mainly related to the loss of lean tissue (Kotler, Tierney, Wang, & Pierson Jr, 1989). The loss of 5% of body weight can increase the risk of death by 2.5 times (Faintuch et al., 2006). Providing nutritional support is fundamental to prevent morbidity, and reduce the risk of mortality among PLHIV with a low BMI or who have rapidly lost weight.

The role of nutrient supplements in PLHIV's nutrition and health

For PLHIV with low BMI or who have experienced rapid weight loss, nutrient supplements aim primarily at supporting weight gain to reduce mortality risk,

rebuilding lean tissue, and improving the immune function (Saskia De Pee & Richard D Semba, 2010; Denise Evans et al., 2013; M. F. Olsen et al., 2014). To rebuild lean tissue, high-quality protein is required. Micronutrients and some amino acids are also needed for antioxidant pathways and to improve the immune function (Scrimshaw & SanGiovanni, 1997). PLHIV need to consume 10-30 % more energy, 12-15 % of the energy should be in the form of protein, and micronutrient intake should be at the level of at least 1-RNI (Recommended Nutrient Intake) (Forrester & Sztam, 2011b; WHO, 2003). Meeting these energy and nutrient requirements is crucial to ensure optimal nutrition and health status among PLHIV.

However, for food-insecure PLHIV, local foods that are good sources of high-quality protein and micronutrients are not affordable in the quantities that they would require. Therefore, in order to meet their nutrient requirements, PLHIV need nutrient supplements to complement their diet. Access to nutrient supplements should be facilitated as early as possible, together with ART and behavior change nutrition education (Saskia De Pee & Richard D Semba, 2010). If the nutrient supplement is in the form of food, and if it is well accepted and consumed frequently, it can also contribute to increasing the acceptability and adherent use of ART (Cantrell et al., 2008).

Food nutrient supplements commonly used for PLHIV in LMIC

In LMIC, lipid-based nutrient supplements [e.g., ready-to-use therapeutic foods (RUTF)] and fortified-blended foods (e.g., Super Cereal) are frequently used for supplementing the diets of adult PLHIV with moderate (BMI ≥ 16 < 18.5) and severe (BMI <16) acute malnutrition. RUTF were originally developed for children (M. J. Manary, 2006). They are a homogenous mix of lipid-rich foods with a nutritional profile similar to the World Health Organization therapeutic milk formula F-100, a product used for treating severe acute malnutrition in children (M. J. Manary, 2006). Primary ingredients of RUTF include peanuts, vegetable oil, sugar, milk powder, and a premix of vitamins and minerals (M. J. Manary, 2006). RUTF can be consumed directly from the sachet and has a 24 months shelf-life. Some studies have indicated that the sensory properties of RUTF, such as its oily texture and high sweet intensity, are disliked by adult PLHIV (F. Dibari, P. Bahwere, et al., 2012; Mesrach Ayalew Kebede & Jemal Haidar, 2014; S. Rodas-Moya, Kodish, Manary, Grede, & de Pee, 2016). Another commonly reported barrier for daily intake of RUTF by adult PLHIV is the large dose prescribed, e.g., 250-500 g/d (Government of Malawi, Ministry of Health, 2006). Kebede and colleagues pointed out that when PLHIV are advised to consume more than two

sachets (~184 g) of RUTF per day, they are not able to comply with the daily dose, particularly for the long period that the product is prescribed, i.e., three to four months (Mesrach Ayalew Kebede & Jemal Haidar, 2014).

Super Cereal (SC) is a fortified-blended food used in food assistance programs to prevent and address nutritional deficiencies among children five years and above, and among adults (WFP, 2011). The primary ingredients of SC are corn, soybeans, vitamins, and minerals, and some also have added sugar (10%). SC is usually consumed as porridge or gruel (WFP, 2011). Although SC seems to be well accepted by PLHIV, issues related to the acceptability of the amount prescribed and its adherent use have been reported (F. Dibari, P. Bahwere, et al., 2012; Mesrach Ayalew Kebede & Jemal Haidar, 2014; Matilsky, Maleta, Castleman, & Manary, 2009; Navarro-Colorado, 2007). The main barrier for its consumption may be the bulk of SC porridge. For PLHIV with moderate acute malnutrition, a daily intake of 1600 kcal from SC porridge is recommended (Government of Malawi, Ministry of Health, 2006). To prepare 1600 kcal of this product, 400 g of SC flour and ~1.2 liters of water are required, which makes ~1.4 kg of SC porridge. Thus, despite its high acceptance and familiarity (Matilsky et al., 2009), ingesting 1.4 kg of porridge daily for 3-4 months is challenging due to bulk, and dietary monotony (Mesrach Ayalew Kebede & Jemal Haidar, 2014). SC and RUTF do not seem to be adequate products for treating undernutrition among adult PLHIV. Hence, alternative nutrient supplements are needed for them.

The influence of culture in the acceptability of food nutrient supplements

Studies conducted in various African countries about the acceptability and perceptions of RUTF and SC have pointed out that these products are considered food or food with medicinal properties (Iuel-Brockdorf et al., 2016; Mette Frahm Olsen, Markos Tesfaye, Pernille Kaestel, Henrik Friis, & Lotte Holm, 2013; S. Rodas-Moya et al., 2016; Santiago Rodas-Moya, Pengnonyang, Kodish, de Pee, & Phanuphak, 2017). Culture largely determines the liking and disliking for food and its sensory characteristics, as well as the context and moment of the day in which foods are consumed (Paul Rozin, 1990; Rozin & Vollmecke, 1986a; Shepherd, 1999). Culture is also related to the beliefs about the nutritional values of food and appropriateness, or inappropriateness, of consuming specific foods in different periods of life and in case of health and disease (Tiu Wright, Nancarrow, & Kwok, 2001). Therefore, to develop a food nutrient supplement with a high potential of acceptability, in-depth knowledge about consumers' preferences for food is needed.

Qualitative research is an excellent resource to investigate cultural preferences for food, the factors that influence food choice among specific population groups, as well as their eating habits (Charmaz, 2014; John W Creswell, 2013; Patton, 2002a). In-depth knowledge of these three dimensions can lead to the identification of appropriate food vehicles for nutritional supplementation. We used qualitative research to investigate the factors that influenced the preferences for food and nutrient supplements among adult PLHIV (Chapters 2 and 3). We also investigated the type of products that they would like to use as nutrient supplements for frequent consumption. We conducted a qualitative study in Malawi (Chapter 2) and another in Thailand (Chapter 3). The objective of undertaking the studies in countries with different cultural contexts was to investigate whether similar factors influenced the preferences for food and nutrient supplements among PLHIV. We also wanted to investigate whether the same product category could be used in an Asian and an African country. Given the high prevalence of food insecurity, undernutrition, and HIV in Malawi, we first focused on developing a product for Malawi.

Development of the nutritious drink samples

Based on the findings from the qualitative study conducted in Malawi, the World Food Programme (WFP) requested DSM to develop a nutritious powdered drink. The nutritious drink had sensory characteristics comparable to a frequently consumed drink in Malawi, i.e., Maheu. Maheu is a thick maize-based drink of sweet and sour flavor and a gritty texture. Eight samples of the nutritious drink were developed for subsequent sensory testing and optimization. The nutritious drink samples had two different intensities of sweetness and sourness and two levels of thickness. Four samples had a flavor mixture to create a taste and smell perception of fermentation, and four samples had no flavor added.

The nutritious drink is fortified with a premix of 22 micronutrients added in ~1 Recommended Nutrient Intake (RNI)/100 g. The nutrient composition of the product was designed for supplementing the diet of adults, in particular, adults living with HIV. For treating mild to moderate undernutrition among PLHIV, the nutrient target of the product is based on a proposed consumption of ~250 ml, twice a day between meals. Two portions (~500 ml or 200 g of powder) provide ~740 kcal and ~80 % of the micronutrients required from a 2500 kcal diet for treating malnutrition (22). The technical specifications of the nutritious drink, including macro and micronutrient composition, can be found in Appendix 1.

Sensory perception of food among PLHIV

The olfactory and gustatory (chemosensory) functions are key systems that allow us to perceive the aroma and flavor of food and drinks (Croy, Nordin, & Hummel, 2014). Therefore, optimal olfactory and gustatory functions are essential for food appraisal and appreciation (Boesveldt, Lindau, McClintock, Hummel, & Lundström, 2011; Brisbois, de Kock, Watanabe, Baracos, & Wismer, 2011; Croy et al., 2014). Taste and smell disorders may affect people's ability to perceive and enjoy food and may change their food preferences. For example, individuals suffering from olfactory and gustatory losses may prefer foods with enhanced flavors and scents (Croy et al., 2014; Giacalone et al., 2016).

Some studies have reported that HIV positive individuals suffer from one or more forms of chemosensory losses (Brody, Serby, Etienne, & Kalkstein, 1991; Hornung et al., 1998; Zucco & Ingegneri, 2004). However, the evidence is inconclusive since various investigators have not found olfactory or gustatory losses among HIV positive people (Fasunla et al., 2016; Mattes, Wysocki, Graziani, & Macgregor, 1995; Mueller, Temmel, Quint, Rieger, & Hummel, 2002). To elucidate whether or not PLHIV in Malawi suffer from chemosensory dysfunction, we assessed the olfactory and gustatory function of a group of adult PLHIV and compared it with that of healthy adults (Chapter 4). The objective of conducting this assessment was to investigate the presence of chemosensory losses, which could explain potential differences in preferences for the nutritious drink samples and the need for enhancing their flavor.

Sensory properties of food and food acceptability

Sensory properties of food, e.g., visual appearance, taste, odor, and texture are among the most important determinants of food choices across cultures (Cunha, Cabral, Moura, & de Almeida, 2018; Fotopoulos, Krystallis, Vassallo, & Pagiaslis, 2009; Monge-Rojas, Mattei, Fuster, Willett, & Campos, 2014; Prescott et al., 2002). Because food nutrient supplements such as RUTF are considered food and are used as food by PLHIV (Iuel-Brockdorf et al., 2016; Mette Frahm Olsen et al., 2013; S. Rodas-Moya et al., 2016; Santiago Rodas-Moya et al., 2017), their acceptability and consumption are highly dependent on their sensory appraisal. For example, the low acceptance reported for RUTF is largely due to its flavor and consistency (intense sweet taste and oily texture) (F. Dibari, P. Bahwere, et al., 2012; Mesrach Ayalew Kebede & Jemal Haidar, 2014). Hence, to improve the acceptability of nutrient supplements, it is crucial to develop products with sensory attributes tailored to the preferences of their potential consumers. A well-accepted product may also

be consumed more frequently, leading to better outcomes in the nutritional status of the consumers.

We used the CATA (check-all-that-apply) questions combined with hedonic scales to develop a sensory characterization of the nutritious drink samples and to assess their sensory acceptability among PLHIV and healthy adults (Chapter 5). We also used penalty analysis to identify the drivers of liking and disliking of the samples and to generate recommendations for optimizing them, tailoring their sensory properties to consumers' preferences (Chapter 5).

We chose the CATA method because it is easy to use for untrained consumers (Gaston Ares, Barreiro, Deliza, Giménez, & Gambaro, 2010; Gastón Ares, Dauber, Fernández, Giménez, & Varela, 2014; G Ares & Jaeger, 2014). The CATA method also generates reliable sensory characterizations of products comparable to those generated by trained sensory panels, which are expensive (Gastón Ares et al., 2015; Dooley, Lee, & Meullenet, 2010; Meyners, Castura, & Carr, 2013) and challenging to find in some low- and middle-income countries. These features from the CATA method interested us because they offer the opportunity to use advanced techniques from sensory science for the development of palatable food nutrient supplements for public health nutrition programs. As far as we know, we are the first group that has used advance sensory science techniques for the development of food nutrient supplements in the context of public health nutrition in LMIC.

Viscosity and food intake

Another sensory property that is crucial for food consumption is texture, precisely viscosity. Viscosity, the variation from liquid to solid, is a determinant factor of satiation (de Graaf, 2012). i.e., the termination of an eating event (Blundell et al., 2010). Therefore, viscosity largely influences the amount of food that one can ingest (de Graaf, 2012). Several studies have demonstrated that people tend to consume a larger volume of food in liquid form than from more viscous food products. These studies have compared solid and semisolid foods and beverages matched for macronutrient composition and energy density. The findings from these studies suggest that despite the similarities in macronutrient composition and energy density of the evaluated products, people consistently consume a more substantial volume from liquids (de Graaf, 2012; Zijlstra, de Wijk, Mars, Stafleu, & de Graaf, 2009; Zijlstra et al., 2008).

Beverages seem to have a weaker satiating effect than more viscous foods because they require less oral processing and have a shorter permanence in the mouth (de Graaf, 2012; Zandstra, de Graaf, & Van Trijp, 2000; Zijlstra

et al., 2009; Zijlstra et al., 2008). Due to the shorter oral residence time of liquids, their taste molecules are less sensed by the taste system and do not remain in the mouth for the time required to trigger satiation (Blundell et al., 2010; de Graaf, 2012). Hence, ingesting a larger volume of liquid is needed until satiation can be reached (de Graaf, 2012; Zijlstra et al., 2009; Zijlstra et al., 2008). Furthermore, liquids are consumed faster than semisolids and solids, and their 'bite-size' is bigger (Zijlstra et al., 2009). The faster consumption and bigger bite-size leads to a higher eating rate, i.e., more grams of liquids are ingested per minute compared to semisolid and solid food (de Graaf, 2012). These characteristics of beverages suggest that using drinks as vehicles for nutritional supplementation could lead to the ingestion of more food and nutrients compared to semisolid products such as RUTF or SC (Chapter 6). In our last study, we compared the ingestion ad libitum of the nutritious drink with the semisolid products RUTF and SC (Chapter 6).

Thesis outline

The research described in this thesis aimed to develop a culturally appropriate nutrient supplement with sensory attributes tailored to the preferences of adults living with and without HIV in Malawi. The sequence of the research is presented in Figure 1.

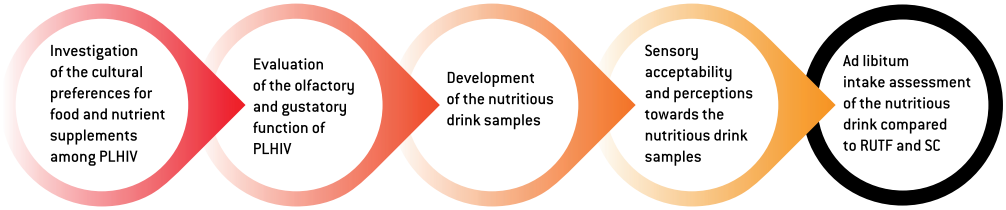

Figure 1. Research sequence for this thesis.

Research objectives

1. To characterize the factors influencing preferences for food and nutrient supplements among PLHIV in Malawi.
2. To characterize the factors influencing preferences for food and nutrient supplements among PLHIV in Thailand to explore differences and commonalities in both countries.
3. To assess the chemosensory function of adults with and without HIV in Malawi.

4. To develop a set of prototypes of nutrient supplements based on the results from the qualitative research in Malawi.
5. To study the sensory acceptability, sensory perception, as well as the drivers of liking and disliking of the eight samples of the nutritious drink among adults with and without HIV.
6. To compare, among PLHIV, the acceptability and intake (ad-libitum) of the nutritious drink with that of RUTF and SC porridge.

The first objective is addressed in Chapter 2. The determinants of preferences for food and nutrient supplements, as well as the eating habits of PLHIV in Malawi, were investigated to identify a culturally appropriate food vehicle for nutritional supplementation. The second objective is addressed in Chapter 3. It contains the results of a similar investigation undertaken in Bangkok, Thailand. The third objective is addressed in Chapter 4. An assessment of the olfactory and gustatory function of adults with and without HIV was conducted to assess whether chemosensory dysfunction could explain potential differences in preferences for the nutritious drink samples and the need of enhancing their flavors to increase liking.

To carry out the fourth objective, based on the results of the qualitative research conducted in Malawi, DSM with the collaboration of WFP developed eight samples of the nutritious drink with different sensory profiles. The fifth objective is addressed in Chapter 5. It describes the sensory acceptability and sensory characterization of the eight samples of the nutritious drink. It also contains recommendations for optimizing three samples of the nutritious drink. The sixth objective is addressed in chapter 6. It compares the ingestion (ad libitum) of the nutritious drink, RUTF, and SC porridge, as well as the caloric and micronutrient intake from each product. This study was conducted only among PLHIV because the nutritious drink was developed primarily for them.

References

Anema, A., Vogenthaler, N., Frongillo, E. A., Kadiyala, S., & Weiser, S. D. (2009). Food insecurity and HIV/AIDS: current knowledge, gaps, and research priorities. *Current HIV/AIDS Reports, 6* (4), 224-231.

Bloem, M. W., & Saadeh, R. (2010). Foreword: the role of nutrition and food insecurity in HIV and tuberculosis infections and the implications for interventions in resource-limited settings. *Food and nutrition bulletin, 31*(4_suppl4), S289-S291.

Blundell, J., de Graaf, C., Hulshof, T., Jebb, S., Livingstone, B., Lluch, A., . . . Westerterp, M. (2010). Appetite control: methodological aspects of the evaluation of foods. *Obes Rev, 11*(3), 251-270. doi:10.1111/j.1467-789X.2010.00714.x

Boesveldt, S., Lindau, S. T., McClintock, M. K., Hummel, T., & Lundström, J. N. (2011). Gustatory and olfactory dysfunction in older adults: a national probability study. *Rhinology, 49*(3), 324.

Brisbois, T. D., de Kock, I. H., Watanabe, S. M., Baracos, V. E., & Wismer, W. V. (2011). Characterization of chemosensory alterations in advanced cancer reveals specific chemosensory phenotypes impacting dietary intake and quality of life. *Journal of pain and symptom management, 41*(4), 673-683.

Brody, D., Serby, M., Etienne, N., & Kalkstein, D. S. (1991). Olfactory identification deficits in HIV infection. *Am J Psychiatry, 148*(2), 248-250.

Cantrell, R. A., Sinkala, M., Megazinni, K., Lawson-Marriott, S., Washington, S., Chi, B. H., . . . Mulenga, L. (2008). A pilot study of food supplementation to improve adherence to antiretroviral therapy among food insecure adults in Lusaka, Zambia. *Journal of acquired immune deficiency syndromes (1999), 49*(2).

Charmaz, K. (2014). *Constructing grounded theory*: Sage.

Creswell, J. W. (2013). *Qualitative inquiry and research design: Choosing among five approaches*: Sage.

Croy, I., Nordin, S., & Hummel, T. (2014). Olfactory disorders and quality of life—an updated review. *Chemical senses, 39*(3), 185-194.

Cunha, L. M., Cabral, D., Moura, A. P., & de Almeida, M. D. V. (2018). Application of the Food Choice Questionnaire across cultures: Systematic review of cross-cultural and single country studies. *Food Quality and Preference, 64*, 21-36.

de Graaf, C. (2012). Texture and satiation: the role of oro-sensory exposure time. *Physiology & behavior, 107*(4), 496-501.

De Pee, S., & Semba, R. D. (2010). Role of nutrition in HIV infection: review of evidence for more effective programming in resource-limited settings. *Food and nutrition bulletin, 31*(4 suppl4), S313-S344.

Dibari, F., Bahwere, P., Le Gall, I., Guerrero, S., Mwaniki, D., & Seal, A. (2012). A qualitative investigation of adherence to nutritional therapy in malnourished adult AIDS patients in Kenya. *Public Health Nutr, 15*(2), 316-323. doi:10.1017/S1368980010003435

Evans, D., McNamara, L., Maskew, M., Selibas, K., van Amsterdam, D., Baines, N., . . . Sanne, I. (2013). Impact of nutritional supplementation on immune response, body mass index and bioelectrical impedance in HIV-positive patients starting antiretroviral therapy. *Nutrition journal, 12*(1), 111.

Faintuch, J., Soeters, P. B., & Osmo, H. G. (2006). Nutritional and metabolic abnormalities in pre-AIDS HIV infection. *Nutrition, 22*(6), 683-690.

FAO, I., UNICEF, WFP and WHO. (2018). *FAO, IFAD, and WFP. The State of Food insecurity in the World 2018. Building climate resilience for food security and nutrition.* . Retrieved from http://www.fao.org/3/I9553EN/i9553en.pdf

Fasunla, A. J., Daniel, A., Nwankwo, U., Kuti, K. M., Nwaorgu, O. G., & Akinyinka, O. O. (2016). Evaluation of Olfactory and Gustatory Function of HIV Infected Women. *AIDS research and treatment, 2016*.

Forrester, J. E., & Sztam, K. A. (2011). Micronutrients in HIV/AIDS: is there evidence to change the WHO 2003 recommendations?–. *The American journal of clinical nutrition, 94*(6), 1683S-1689S.

Fotopoulos, C., Krystallis, A., Vassallo, M., & Pagiaslis, A. (2009). Food Choice Questionnaire (FCQ) revisited. Suggestions for the development of an enhanced general food motivation model. *Appetite, 52*(1), 199-208.

Giacalone, D., Wendin, K., Kremer, S., Frøst, M. B., Bredie, W. L., Olsson, V., . . . Risvik, E. (2016). Health and quality of life in an aging population–Food and beyond. *Food Quality and Preference, 47*, 166-170.

Haddad, L. J., Hawkes, C., Achadi, E., Ahuja, A., Ag Bendech, M., Bhatia, K., . . . Eriksen, K. (2018). *Global Nutrition Report 2018: Actions and accountability to advance nutrition and sustainable development*: Intl Food Policy Res Inst.

Hornung, D. E., Kurtz, D. B., Bradshaw, C. B., Seipel, D. M., Kent, P. F., Blair, D. C., & Emko, P. (1998). The olfactory loss that accompanies an HIV infection. *Physiology & behavior, 64*(4), 549-556.

Isaac, R., Jacobson, D., Wanke, C., Hendricks, K., Knox, T. A., & Wilson, I. B. (2008). Declines in dietary macronutrient intake in persons with HIV infection who develop depression. *Public health nutrition, 11*(2), 124-131.

Iuel-Brockdorf, A.-S., Draebel, T. A., Ritz, C., Fabiansen, C., Cichon, B., Christensen, V. B., . . . Michaelsen, K. F. (2016). Evaluation of the acceptability of improved supplementary foods for the treatment of moderate acute malnutrition in Burkina Faso using a mixed method approach. *Appetite, 99*, 34-45.

Kebede, M. A., & Haidar, J. (2014). Factors influencing adherence to the food by prescription program among adult HIV positive patients in Addis Ababa, Ethiopia: a facility-based, cross-sectional study. *Infectious diseases of poverty, 3*(1), 20.

Kotler, D. P., Tierney, A. R., Wang, J., & Pierson Jr, R. N. (1989). Magnitude of body-cell-mass depletion and the timing of death from wasting in AIDS. *The American journal of clinical nutrition, 50*(3), 444-447.

Manary, M. J. (2006). Local production and provision of ready-to-use therapeutic food (RUTF) spread for the treatment of severe childhood malnutrition. *Food and nutrition bulletin, 27*(3_suppl3), S83-S89.

Mangili, A., Murman, D., Zampini, A., Wanke, C., & Mayer, K. H. (2006). Nutrition and HIV infection: review of weight loss and wasting in the era of highly active antiretroviral therapy from the nutrition for healthy living cohort. *Clinical Infectious Diseases, 42*(6), 836-842.

Matilsky, D. K., Maleta, K., Castleman, T., & Manary, M. J. (2009). Supplementary feeding with fortified spreads results in higher recovery rates than with a corn/soy blend in moderately wasted children. *The Journal of nutrition, 139*(4), 773-778.

Mattes, R. D., Wysocki, C. J., Graziani, A., & Macgregor, R. R. (1995). Chemosensory function and diet in HIV infected patients. *The Laryngoscope, 105*(8), 862-866.

Ministry of Health, Government of Malawi. (2006). Interim Guidelines for the Management of Acute Malnutrition in Adolescents and Adults.

Monge-Rojas, R., Mattei, J., Fuster, T., Willett, W., & Campos, H. (2014). Influence of sensory and cultural perceptions of white rice, brown rice and beans by Costa Rican adults in their dietary choices. *Appetite, 81*, 200-208.

Mueller, C., Temmel, A., Quint, C., Rieger, A., & Hummel, T. (2002). Olfactory function in HIV-positive subjects. *Acta oto-laryngologica, 122*(1), 67-71.

Navarro-Colorado, C. (2007). A retrospective study of emergency supplementary feeding programmes. *Save the Children/ENN Available at: http://www. ennonline. net/pool/files/research/Retrospective_Study_of_Emergency_ Supplementary_Feeding_Programmes_June, 202007*.

Olsen, M. F., Abdissa, A., Kæstel, P., Tesfaye, M., Yilma, D., Girma, T., . . . Michaelsen, K. F. (2014). Effects of nutritional supplementation for HIV patients starting antiretroviral treatment: randomised controlled trial in Ethiopia. *Bmj, 348*, g3187.

Olsen, M. F., Tesfaye, M., Kaestel, P., Friis, H., & Holm, L. (2013). Use, perceptions, and acceptability of a ready-to-use supplementary food among adult HIV patients initiating antiretroviral treatment: a qualitative study in Ethiopia. *Patient preference and adherence, 7*, 481.

Patton, M. Q. (2002). *Qualitative research & evaluation methods : integrating theory and practice* (Fourth edition. ed.). Thousand Oaks, California: SAGE Publications, Inc.

Pinstrup-Andersen, P. (2009). Food security: definition and measurement. *Food security, 1*(1), 5-7.

Prescott, J., Young, O., O'neill, L., Yau, N., & Stevens, R. (2002). Motives for food choice: a comparison of consumers from Japan, Taiwan, Malaysia and New Zealand. *Food Quality and Preference, 13*(7-8), 489-495.

Rodas-Moya, S., Kodish, S., Manary, M., Grede, N., & de Pee, S. (2016). Preferences for food and nutritional supplements among adult people living with HIV in Malawi. *Public Health Nutr, 19*(4), 693-702. doi:10.1017/S1368980015001822

Rodas-Moya, S., Pengnonyang, S., Kodish, S., de Pee, S., & Phanuphak, P. (2017). Psychosocial factors influencing preferences for food and nutritional supplements among people living with HIV in Bangkok, Thailand. *Appetite, 108*, 498-505.

Rollins, N. (2007). Food insecurity—a risk factor for HIV infection. *PLoS Medicine, 4*(10), e301.

Rozin, P. (1990). Acquisition of stable food preferences. *Nutrition reviews, 48*(2), 106-113.

Rozin, P., & Vollmecke, T. A. (1986). Food likes and dislikes. *Annu Rev Nutr, 6*, 433-456. doi:10.1146/annurev.nu.06.070186.002245

Scrimshaw, N. S., & SanGiovanni, J. P. (1997). Synergism of nutrition, infection, and immunity: an overview. *The American journal of clinical nutrition, 66*(2), 464S-477S.

Shepherd, R. (1999). Social determinants of food choice. *Proceedings of the Nutrition Society, 58*(4), 807-812.

Swinburn, B. A., Kraak, V. I., Allender, S., Atkins, V. J., Baker, P. I., Bogard, J. R., . . . Devarajan, R. (2019). The global syndemic of obesity, undernutrition, and climate change: The Lancet Commission report. *The Lancet, 393*(10173), 791-846.

SZCZESNIAK, A. S. (1991). Textural perceptions and food quality 1. *Journal of Food Quality, 14*(1), 75-85.

Tiu Wright, L., Nancarrow, C., & Kwok, P. M. (2001). Food taste preferences and cultural influences on consumption. *British Food Journal, 103*(5), 348-357.

Tiyou, A., Belachew, T., Alemseged, F., & Biadgilign, S. (2012). Food insecurity and associated factors among HIV-infected individuals receiving highly active antiretroviral therapy in Jimma zone Southwest Ethiopia. *Nutrition journal, 11*(1), 51.

Wanke, C., Kotler, D., & Committee, H. W. C. C. (2004). Collaborative recommendations: the approach to diagnosis and treatment of HIV wasting. *JAIDS Journal of Acquired Immune Deficiency Syndromes, 37*, S284-S288.

WFP. (2011). Technical Specifications for the Manufacture of: Super Cereal (Corn Soya Blend).

WHO. (2003). Nutrient requirements for people living with HIV/AIDS. 7-8.

Zandstra, E. H., de Graaf, C., & Van Trijp, H. C. (2000). Effects of variety and repeated in-home consumption on product acceptance. *Appetite, 35*(2), 113-119.

Zijlstra, N., de Wijk, R., Mars, M., Stafleu, A., & de Graaf, C. (2009). Effect of bite size and oral processing time of a semisolid food on satiation. *The American journal of clinical nutrition, 90*(2), 269-275.

Zijlstra, N., Mars, M., de Wijk, R. A., Westerterp-Plantenga, M. S., & de Graaf, C. (2008). The effect of viscosity on ad libitum food intake. *International journal of obesity, 32*(4), 676.

Zucco, G. M., & Ingegneri, G. (2004). Olfactory deficits in HIV-infected patients with and without AIDS dementia complex. *Physiology & behavior, 80*(5), 669-674.

Chapter 2

Preferences for food and nutrient supplements among people living with HIV (PLHIV) in Malawi

Santiago Rodas-Moya
Stephen Kodish
Mark Manary
Nils Grede
Saskia de Pee

Published (Public Health Nutrition Journal)

ABSTRACT

The objective of this paper was to elucidate the factors influencing food intake and preferences for potential nutritional supplements to treat mild and moderate malnutrition among adults living with HIV. Qualitative research using in-depth interviews with a triangulation of participants and an iterative approach to data collection. The study was conducted in a health clinic of rural Chilomoni, a southern town of Blantyre district, Malawi. Male and female participants, aged 18-49 years (*n*=24) affected by HIV, and health surveillance assistants (HSAs) of Chilomoni clinic (*n*=8) participated. Six themes emerged from the in-depth interviews: 1) adult people living with HIV (PLHIV) perceived having a poor-quality diet, 2) health challenges determine the preferences of PLHIV for food, 3) liquid-thick, soft textures, and subtle natural colors and flavors are preferred, 4) preferred sensory properties of nutritional supplements resemble those of local foods, 5) food insecurity may contribute to intra-household sharing of nutritional supplements, and 6) HSAs and family members influence PLHIV dietary behaviors. No gender differences were found. The emergent themes were corroborated by HSAs through participant triangulation. In this setting, a thickened liquid supplement, slightly sweet and sour, may be well accepted. A combination of descriptive and affective sensorial tests should follow to fine-tune the sensory properties of the product to the taste and requirements of PLHIV. Results of this study may only be transferable to settings with similar cultures and food preferences.

INTRODUCTION

Malnutrition and HIV are often coincident. HIV infection can lead to malnutrition, while a poor diet can accelerate the progression and increase the severity of HIV disease (A. Anema, N. Vogenthaler, E. A. Frongillo, S. Kadiyala, & S. D. Weiser, 2009). HIV affects dietary intake and the utilization of food. When untreated, a combination of symptoms, such as anorexia, nausea, vomiting, difficulty swallowing, changes in the gastric mucosa, gastrointestinal infections and altered gut barrier function limit food intake and utilization even further (S. de Pee & R. D. Semba, 2010; C. Wanke & Kotler, 2004). Moreover, HIV infection results in increased resting energy expenditure (10% to 30%), a faster rate of utilization of amino acids to fuel energy needs, altered fat accumulation and lack of preservation and restoration of lean tissue. Together, these metabolic changes can result in HIV-associated wasting syndrome (body weight loss ≥ 10 % or BMI < 18.5 kg/m2) (A. Anema et al., 2009; S. de Pee & R. D. Semba, 2010; J. R. Koethe, B. H. Chi, K. M. Megazzini, D. C. Heimburger, & J. S. A. Stringer, 2009; C. Wanke & Kotler, 2004).

While access to antiretroviral therapy (ART) has increased in African countries (J. R. Koethe et al., 2009; UNAIDS., 2010) and has contributed to improving immune system function and the overall health of people living with HIV (PLHIV) (Berhe, Tegabu, & Alemayehu, 2013), questions are emerging about how well drugs work in PLHIV if they are food insecure (Frega, Duffy, Rawat, & Grede, 2010). Studies show that malnutrition and food insecurity remain significant obstacles to treatment and improved outcomes for PLHIV (M. W. Bloem & R. Saadeh, 2010; Frega et al., 2010; Semba, Darnton-Hill, & de Pee, 2010). Moreover, being malnourished at the start of ART can increase the risk of death up to six times (J. R. Koethe et al., 2009). Food insecurity has been correlated with reduced adherence to ART regimens (A. Tiyou, T. Belachew, F. Alemseged, & S. Biadgilign, 2012), increased behavioral risk of transmission and decreased access to care (A. Anema et al., 2009; N. Rollins, 2007; A. Tiyou et al., 2012).

The interrelationship between HIV, tuberculosis (TB) and malnutrition also has important health implications. Changes in metabolism, immune status and nutrient absorption are exacerbated by HIV and TB co-infection, making it even more difficult for people who have both diseases to remain properly nourished and increasing their risk of death (M. W. Bloem & R. Saadeh, 2010; Macallan, 1999; Semba et al., 2010). In Sub-Saharan Africa, HIV-TB co-infections affect nearly 80% of PLHIV (UNAIDS., 2010).

Nutritional supplementation has been shown to be effective in improving HIV and TB outcomes (S. de Pee & R. D. Semba, 2010; Semba et al., 2010). However, supplement options for treating malnutrition in adults remain limited. Nutritional supplements that are often used in developing countries are fortified blended foods (FBF) (i.e. corn-soy blends –CSB- and peanut-based ready to use therapeutic foods –RUTF-)(S. de Pee & R. D. Semba, 2010). In Malawi, to treat severely malnourished adult PLHIV (BMI < 16 kg/m2), protocols from the Ministry of Health (MoH) indicate the prescription of ~ 550 g/d of RUTF (~3000 kcal/d) (G. Ministry of Health, March 2006). To treat moderately malnourished adults (BMI < 18.5 kg/m2) ~270 g/d of RUTF (~ 1500 kcal/d) are prescribed. Alternatively, 9 kg of CSB and 1 liter of vegetable oil are provided per month and are advised to be consumed in amounts providing ~1500 kcal/d (G. Ministry of Health, March 2006).

Although studies have reported that RUTF consumption by adult PLHIV restored BMI relatively quickly (L. Ahoua et al., 2011; Bahwere, Sadler, & Collins, 2009; M. Manary, Ndekha, & van Oosterhout, 2010) and faster than CSB (M. Manary et al., 2010), there are issues with its acceptance. These issues include sensorial factors such as taste and consistency (e.g. too sweet, too salty and

too oily) (F. Dibari, P. Bahwere, et al., 2012), as well as dietary monotony (F. Dibari, P. Bahwere, et al., 2012; M. F. Olsen, M. Tesfaye, P. Kaestel, H. Friis, & L. Holm, 2013). Aspects such as poor knowledge on the benefits of RUTF, the duration of the nutritional programs (e.g. more than 4 months), the perceived high daily prescribed amounts, sharing with family members and selling the product in order to obtain other foods, have also been reported as barriers to the acceptability of RUTF (M. A. Kebede & J. Haidar, 2014).

Moreover, RUTF and CSB were developed for treating acute malnutrition in children and appear to be less well accepted by adults (S. de Pee & R. D. Semba, 2010; F. Dibari, P. Bahwere, et al., 2012; G. Ministry of Health, March 2006). Furthermore, when consuming RUTF, which was originally developed for children, as the main source of energy, the absolute intake of some nutrients, particularly iron, zinc and copper, is high for adults (S. de Pee & R. D. Semba, 2010). In this context, developing culturally adapted nutritional supplements that also take into consideration the clinical and nutritional needs of PLHIV is critical. The aim of this study was to elucidate the factors influencing food intake and preferences among adults living with HIV in Malawi and to solicit their responses to four different types of potential nutritional supplements. We sought this information in order to inform the development of alternative supplementary foods to treat mild and moderate malnutrition among adult PLHIV.

METHODS

Study sample

A purposeful sample (Patton, 2002b) of nine male and 15 female adults living with HIV aged 22 to 49 years from rural communities of Chilomoni area near Blantyre city, Malawi was selected. Criterion-based purposeful sampling included participants suffering from mouth sores, HIV-TB co-infection, diarrhea, and other health challenges related to HIV. Participants were recruited with the assistance of health care personnel from the Chilomoni clinic.

To triangulate data sources (Patton, 2002b; Sandelowski, 2000), 8 health surveillance assistants (HSAs) were also interviewed. HSAs are paid government health care workers who perform health promotion activities in the communities they serve and at the clinic. HSAs have rich knowledge of the health and social conditions of PLHIV. In total, 32 in-depth interviews (IDIs) were conducted until data saturation was reached (i.e. the point in data collection when no new or relevant information emerges with respect to the newly constructed theory). To highlight areas of contrast or exceptions

to dominant patterns, a deviant case was identified and studied through purposeful sampling (Sandelowski, 2000; Teddlie & Yu, 2007). The deviant case is a PLHIV who was stigmatized by his family members and was living alone. HSAs indicated that currently, the majority of PLHIV live with one or more family members who generally provide them with economic and emotional support.

Data collection

A data collection team of four social scientists, bilingual in Chichewa and English, was recruited from the local area and trained for 40 hours in qualitative, in-depth, interviewing theory and techniques. Semi-structured IDI guides were developed in English, translated by data collectors from English to Chichewa and then translated back from Chichewa to English to ensure accuracy. The IDI guides were field-tested for comprehension among people possessing similar characteristics to those of the study population.

One-on-one IDIs were conducted at Chilomoni clinic, Blantyre over a five-week period. IDIs aimed to explore: (1) food preferences of PLHIV, (2) the factors that influence their food preferences and (3) perceptions on the sensory characteristics (i.e. color, odor, flavor, texture and appearance) of four sample food products. Perceptions of each product were explored in depth. The IDIs were digitally recorded, each lasting between 60 and 75 minutes. Each data collector conducted, transcribed and translated approximately two IDIs per week to allow the main researcher ample time for data immersion and subsequent interview planning (Matthew B. Miles, Huberman, & Saldaña, 2014). This process was follow iteratively until data saturation was reached. To collect information on gender, age, income and education level, a socio-demographic questionnaire was also administered.

Description of the four potential nutritional supplements

In order to solicit responses to different types of food products, which could in principle be adjusted in terms of nutrient densities to be appropriate for treating malnutrition, the following four products were offered to participants: cream-filled chocolate cereals (pillow-shaped ~2.5 X 2.5 cm, with a hard crunchy texture outside and a soft chocolate filling inside), fruit bars (dark brown bars of ~6 X 3 cm, a soft consistency, sweet and sour flavors made with citric fruits and peanuts), a high energy round butternut biscuit, slightly sweet and salty (similar to the High Energy Biscuits (HEBs)

used by the World Food Programme (WFP) in emergency operations and school feeding), and a locally-produced chocolate milkshake slightly thick and packed in a 300 ml bottle.

Samples of the cream-filled cereals were packed by the manufacturer in plastic containers of ~500 g and were re-packed by researchers in plastic zip-lock bags containing 8 units (i.e., 8 pillow-shaped ~2.5 X 2.5 cm units). The fruit bars were packed by the manufacturer in individual white soft plastic wrapping material and showed an expiration date. The butternut biscuits were packed by the manufacturer in silver soft plastic material and also had an expiration date indicated. The milkshake was packed in a hard-plastic bottle of 300 ml with a plastic screw cap and a breakable plastic seal. This was a branded product with a picture showing the milkshake, a list of ingredients, nutrition facts, and a use-by date was indicated.

Data analysis

Qualitative data analysis was conducted following content analysis procedures as discussed by Miles and Huberman (Matthew B. Miles et al., 2014). The transcripts were entered in Atlas ti v.6.1 (John W. Creswell & Creswell, 2013; Matthew B. Miles et al., 2014). The IDIs were first read several times by the main researchers to get a holistic view of the data. Then, a list of codes containing 25 categories of information (codes) was developed in the data analysis software from emerging themes. The codes were aggregated to paragraphs of text to detect recurring patterns. The 25 codes were then clustered and merged into 9 pattern codes. Interrelations between pattern codes were constructed to develop 6 main categories for theory building. A crossed comparison of the coded passages was conducted from the two data sources: PLHIV (n=24), and HSAs (n=8). Data from the deviant case that did not fit the dominant patterns were utilized to examine divergences and add detail to descriptions. The quotations that best described PLHIV's experiences were used to illustrate findings.

RESULTS

Twenty-four PLHIV and 8 HSAs participated in the study. In total, 32 IDIs were conducted. BMI and demographic characteristics of participants are presented in table 2.1.

Table 2.1. BMI and demographic characteristics of participants

Characteristics of participants				No of participants
BMI (kg/m2)†	Undernourished	< 18.5		7
	Normal wt.	≥ 18.5 to 24.99		11
	Overweight	≥ 25 to ≤ 29.99		5
	Missing data	-		1
Age	**Years**	**Mean**	**SD‡**	
	18-49	31.9	9.2	24
Gender	Male			9
	Female			15
Education	No education			2
	Some primary school			14
	Completed primary school			1
	Some secondary school			4
	Completed secondary school			1
	More than secondary school			2
Household Monthly Income in MKW§	0-6000			15
	6001-12 000			5
	> 12000			4

† Body mass index was calculated from weight and height obtained from participant's medical records.

‡ Standard Deviation.

§ MKW = Malawian Kwachas. (Exchange rate when conducting the study: USD $ 1 = 250 MKW)

Health challenges of participants are presented in Table 2.2.

Table 2.2. Health characteristics of participants

Health Challenge	No. of participants not enrolled on ART†	No. of Participants enrolled on ART	Total No. of participants
HIV and mouth sores	1	6	7
HIV and diarrhea	-	4	4
HIV and TB	1	5	6
HIV with different health concerns††	5	2	7
Totals	7	17	24

† Patients with a CD4 count >250 cells/mm3 (cut off point for enrollment on ART when the study was conducted)

†† Different health concerns included malaria, body pain, headache, fever, palpitations, among others.

From 32 verbatim transcripts, we extracted 6 thematic categories that are presented in the following sections. Data are supported with quotes that represent the perceptions that male and female participants with different health challenges had with respect to the emerging themes.

Theme 1: Adult PLHIV perceived having a poor-quality diet

All participants indicated that their access to food is limited, particularly to foods from animal sources. The majority of participants described their diet as 'simple' and 'insufficient to provide energy to fight the virus' and to provide 'strength for work'. Most of the participants indicated that they 'don't have enough to eat'. A 28-year-old male participant not on ART explained:

'... a diet that can't have more than nsima (stiff maize porridge) and some vegetables can't be good. I can get full from nsima, but this is not enough. I need food that adds blood in my body, so I can have strength to work and to fight the disease. I depend on my sister; she buys food, but we have to split with 5.'

For all participants, limited economic access to food leads to the consumption of nsima and parboiled green leafs, sometimes accompanied with ground nuts and rarely with small fish. The majority of participants indicated that the food they eat cannot 'add blood in the body.' When exploring how food can add blood in their body, most of the participants indicated that 'food with proteins and vitamins', such as 'big fish (e.g. chambo),' 'meat,' 'chicken,' and 'milk', can do so because they 'give energy and strength to live,' 'energy for work' and help to 'fight the virus' (referring to HIV). All participants relate the consumption of nsima and green leaves with a poor diet that can't provide the required energy for day-to-day life. Unanimously, HSAs indicated that the majority of PLHIV are food insecure and rely on their families for food.

Theme 2: Health challenges determine preferences of PLHIV for food

Food preferences are largely driven by health challenges. Participants who had mouth sores indicated preference for foods of soft and liquid consistencies because they do not require chewing and are easy to swallow; which prevents them from experiencing mouth pain when eating (Table2.3., comment 2.3.1).

Table 2.3. Health challenges and food preferences

Mouth sores	
2.3.1.	'I can't chew. It hurts deep inside my mouth. When I'm hungry I eat some porridge, tea or juice because it's easier to swallow than nsima.'
2.3.2.	'I need to refresh my mouth and to make it feel the taste... I can't taste the flavor of food.'
2.3.3.	'I like orange juice, malambe† juice, mbwemba‡. Sour fruits help to cure the sores.'
Diarrhea	
2.3.4.	'I have a running stomach. Everything I eat goes out, I feel so tired I don't want to eat. I prefer to drink something to calm my thirst.'
2.3.5.	'I often have a running stomach and when I am like this I also have nausea, I don't feel like eating. I tried to eat an orange, or drink orange squash, some mbwemba to get the vitamins to fight the disease.'
2.3.6.	'I don't eat nsima because I have trouble in my stomach after eating.'
HIV/TB co-infection	
2.3.7.	'I feel so weak. I feel the need of coughing quite often and that makes me nauseous. I avoid food and just drink something...'
2.3.8.	'Chewing makes me feel exhausted. I prefer a drink or make a liquid porridge to get some strength.'
2.3.9.	'I can eat small portions of foods, but they need to be soft so I don't have to chew them...'

†Malambe is a sour fruit from the Baobab tree.

‡ Means tamarind in Chichewa language.

Participants under this category also indicated that they need to refresh their mouth constantly and that they can't feel the taste of food. These were indicated as reasons for preferring sour fruits and drinks (Table 2.3., comment 2.3.2). Another important reason for consuming sour foods is the cultural belief that sourness can help cure sores (Table 2.3., comment 2.3.3). The majority of PLHIV participants indicated that sour foods and drinks help them recover from periods of illness. HSAs indicated that the perception toward the curative properties of sour foods and drinks is a well-established cultural belief in Malawi.

Participants who had diarrhea complained of nausea as well and indicated experiencing fatigue and thirst. The sensation of tiredness, thirst and the perceived inability to retain food because of the diarrhea were indicated as reasons for consuming liquid instead of solid food (Table 2.3., comment 2.3.4-2.3.6).

PLHIV suffering from TB indicated that TB and HIV make them feel extremely tired. They indicated coughing often and feeling nauseous when coughing (Table 2.3, comment 2.3.7). Participants in this category also indicated preference for soft and easy to chew foods and liquids (Table 2.3. Comment 2.3.8). They also indicated eating small portions of food throughout the day (Table 2.3., comment 2.3.9).

Unanimously, HSAs indicated that in general, PLHIV eat small portions of food because they are not hungry and get easily tired while eating which also makes them prefer soft foods such as nsima, porridge, and liquids.

Theme 3: Liquid-thick, soft textures and subtle natural colors and flavors are preferred

Unanimously, participants indicated a preference for foods with soft consistencies, natural subtle flavors and colors, and foods that they perceive to be 'real foods' which they commonly eat. A typical breakfast consists of tea, or coffee served with tubers and nsima or porridge (Table 2.4, comments 2.4.1, 2.4.2).

Table 2.4. PLHIV's preferences for food and eating habits

Breakfast	
2.4.1.	'Our food is natural. I boil water to make some tea, sometimes coffee and drink it with sweet potatoes, cassava or potatoes.'
2.4.2.	'I make some coffee to eat with nsima, sometimes I eat porridge instead.'
Lunch	
2.4.3	'I eat 1 piece of nsima† with pumpkin leaves and sometimes I put ground nuts on my nsima. I can also eat beans as relish.'
2.4.4.	'My sister boils mustard leaves, sometimes she mixes them with amaranths leaves, or blackjack leaves. We cook them with onions and tomatoes and we serve this as relish with 2 pieces of nsima.'
2.4.5.	'I like to eat natural foods. I just add a little bit of salt. I don't like the flavor of food with condiments. When flavors are to strong I feel like puking.'
2.4.6.	'I don't like fried foods. They are too greasy. It makes me nauseous.'
2.4.7.	'Oil is very expensive. Sometimes I buy a small bag in the kiosk.'
Dinner	
2.4.8.	'When available, we eat leftovers of lunch. Otherwise, just a coffee or tea with some bread, cassava, or a sweet potato.'

Snack‡

2.4.9. I tried to eat oranges. They have vitamin C that helps to fight the virus.'

2.4.10. 'The HSAs recommend oranges for the vitamin C.'

2.4.11. 'I like to eat Papaya. It refreshes my mouth and has the vitamins.'

2.4.12. 'Sometimes I drink malambe juice. It is sour and helps to cure the colds.'

2.4.13. 'I tried to eat bwemba (tamarind) for the sores. That is cheap and helps to keep my mouth dry.'

---

† ~ 1-cup.

‡ Occasional consumption of fruits as snacks was indicated for 9 of the 24 PLHIV participants.

Lunch often consists of nsima or porridge served with parboiled green leaves. Sometimes ground nuts are added (Table 2.4., comments 2.4.3, 2.4.4). When exploring the kind of seasoning used to prepare foods, the majority of participants indicated that they dislike strong flavors, and that they like to feel the natural flavors of food. All participants indicated that they don't use condiments. (Table 2.4., comment 2.4.5). Most of the participants indicated a disliking of fried foods (Table 2.4., comment 2.4.6). In addition, oil was perceived expensive and only small bags (containing a couple of tablespoons) were purchased occasionally (Table 2.4., comment 2.4.7). Dinner usually consists of leftovers from lunch (when available), or coffee served with a piece of bread or tubers (Table 2.4., comment 2.4.8). Few participants indicated eating snacks. Those who were able to eat snacks indicated preferences for fruits, fruit juices, and orange squash because they are considered refreshing and rich in vitamins (Table 2.4., comments 2.4.9-2.4.13). No differences in food preferences among participants enrolled on ART and those who were not (yet) eligible for ART emerged. Descriptions provided by HSAs about the typical diet of PLHIV were more general, but consistent with the aforementioned eating patterns. However, HSAs indicated that the majority of PLHIV have only two meals per day.

Theme 4: Preferred organoleptic characteristics of nutritional supplements resemble those indicated for local foods

Chocolate milkshake (Local product)

All participants identified the product as a chocolate milk shake (Table 2.5., comment 2.5.1).

Table 2.5. Perceptions of potential supplements

Chocolate milkshake (Slightly thick packed in a 300 ml bottle)
2.5.1. 'This is a drink made with milk and chocolate. I can easily take with me and drink it.'
2.5.2. 'If I go and drink it out people will be jealous. Looks so luxurious it has milk.'
2.5.3. 'It is tasty. So refreshing. I would take it and drink it everywhere. People will think that I have money... It has milk.'
2.5.4. 'This one has the energy and strength that I need to work.'
2.5.5. 'The color makes me think it is too sweet (chocolate) and we, PLHIV, hate sugar, but when I tried it, it is not so sweet. I like it, but I would prefer something fruity.'
2.5.6. 'It's good but needs to be a bit thicker, so you feel that you are eating something nutritious. Add some fruits instead of chocolate.'
Fruit bars (dark brown bar of 6 x 3 cm approx., soft consistency, sweet and sour flavors made with citric fruits and peanuts)
2.5.7. 'It is too sweet. I can't recognize what it's made of.'
2.5.8. 'The color looks like there is something bad in there. It's not natural.'
2.5.9. 'It's sticky and rough. It can stick to my sores and teeth. Not good...'
2.5.10. 'This doesn't look like something that can help us.'
2.5.11. 'Looks like it is difficult to digest.'
Cream filled chocolate cereals (pillow shaped 2.5 x 2.5 cm approx., with a hard crunchy texture outside and a soft chocolate filling inside)
2.5.12. 'This looks so strange to me. What is it?'
2.5.13. 'I can't try it I have mouth sores. This looks so hard.'
2.5.14. 'It is so hard, I felt like it dug into my teeth.'
2.5.15. 'The color is so boring.'
2.5.16. 'I don't like the shape. It looks like medicines. When I eat food I want to eat food not medicines.'
Butternut Biscuit (Soft round buttery biscuit slightly sweet and salty)
2.5.17. 'It's a biscuit.'
2.5.18. 'Taste like butter. I don't like butter.'
2.5.19. 'It tastes like medicine... Leaves an after taste.'
2.5.20. 'It's soft, but a bit dry. I would need to eat it with tea.'
2.5.21. 'Boring color.'

Because of the milk, it was perceived as an expensive item that would be appreciated by others as well (Table 2.5., comment 2.5.2). The majority of participants considered the product tasty, refreshing, easy to carry, and a symbol of status (Table 2.5., comment 2.5.3). When exploring perceptions about the overall appearance, the majority of participants indicated that it looks like an energy giving drink (Table 2.5., comment 2.5.4). Some participants however, voiced concern about the color. The chocolate color made them think that the product might be very sweet. Sweetness was an important barrier to the acceptability of foods and drinks (Table 2.5., comment 2.5.5). Although the chocolate milkshake was well accepted, all participants indicated preferences for fruity drinks and thicker textures. Fruits are perceived to be rich in vitamins, and a thick-liquid texture is perceived to be more nutritious (Table 2.5., comments 2.5.5, 2.5.6). All HSA participants indicated that this product would be well accepted by PLHIV, however, they indicated that reducing sugar levels might be necessary to make the product more appealing for PLHIV.

Fruit bar

All participants indicated that they could not recognize the product. The flavor was sensed too sweet, the color was unanimously disliked, perceived unnatural and made all participants think that something was wrong with the product (Table 2.5., comments 2.5.7, 2.5.8). The texture was perceived as sticky and rough which was particularly disliked by PLHIV who had mouth sores. All PLHIV participants indicated that sticky textures are bad for their teeth (Table 2.5., comment 2.5.9). When exploring perceptions about the overall appearance of the product, al participants indicated that it did not look like something that could help them (Table 2.5., comments, 2.5.10). Some PLHIV participants indicated that the product seemed difficult to digest (Table 2.5., comment 2.5.11). The majority of HSAs thought that this product would be well accepted by PLHIV, if sweetness would be reduced. Two HSAs indicated that if the consistency of the fruit bar were softer and less chewy, more PLHIV would like it.

Cream filled chocolate cereals

None of the participants could recognize this product (Table 2.5., comment 2.5.12). The crunchy texture was perceived hard, thus bad for the teeth. All participants with mouth sores refused to try it (Table 2.5., comments 2.5.13, 2.5.14). The creamy color of the outer coat was perceived unattractive. When exploring perceptions about general appearance, some participants indicated that the cereal looked like medicine (Table 2.5., comment 2.5.16) which resulted in a reason to reject the product. All HSAs indicated that the cereals

are 'too hard' and some added that they are 'too dry'. However, the majority of HSAs considered the sweetness to be appropriate for PLHIV, but that this product would not be well accepted by them due to its hard and dry consistencies.

Butternut biscuit

All participants recognized this product and classified it as a biscuit (Table 2.5., comment 2.5.17). The flavor was identified as butter and was disliked by the majority of participants who indicated that leaves an after taste. Some participants also indicated that the biscuit tastes like medicine (Table 2.5., comments 2.5.18, 2.5.19). The texture was perceived soft, but dry and the creamy color was considered unattractive (Table 2.5., comments 2.5.20, 2.5.21). All HSAs perceived this product to be a 'normal biscuit'. However, they indicated that it breaks easily which may make PLHIV believe that it is a product of bad quality. Perceptions of color and texture were similar to those expressed by PLHIV. Some HSAs indicated that the biscuit leaves a 'strange aftertaste' in their mouth.

When exploring perceptions of product packaging, participants consistently indicated a preference for small, rigid, portable packets containing personal servings of food or drinks because they are easy to carry and consume at any time. In addition, most participants indicated that it is important to see 'pictures or drawings showing the contents inside the packets.' The majority of participants also searched for information regarding ingredients and the nutrient contents of the products, as well as directions for appropriate use and their expiration dates. Unanimously, PLHIV participants indicated that the information needs to be written in Chichewa, the local language. Similar perceptions emerged among HSAs who also indicated that they teach PLHIV during counseling activities to read product labels, check the ingredients and look for expiry dates of manufactured products to avoid consuming items past their expiration date as that could be harmful to their health.

Theme 5: Food insecurity may contribute to intra-household sharing of nutritional supplements

Twenty-two out of 24 PLHIV reported being unemployed. They indicated that they rely on their family for food. Furthermore, some participants explained that their communities are far from food markets and from the clinic, which also makes their access to food and health care difficult due to a poor availability of transportation systems and high commuting costs. We found that the distance to food markets and to health care centers particularly affects PLHIV who live alone (the deviant case in this study) because they lack the family support to facilitate economic and physical access to food, as well as physical access to health care.

HSAs indicated that for PLHIV who are living alone, attending to counseling sessions at the clinic may become challenging, particularly when they are ill. They indicated that sometimes they are unable to collect their medicines and nutritional supplements due to the long distances between the clinic and their households. This makes them more vulnerable to food insecurity.

However, all PLHIV participants indicated that 'food is scarce' in their households and that food is shared among all family members. Sharing food emerged as a social norm among all participants. HSAs indicated that nutritional supplements (referring to RUTF and CSB) are considered food by PLHIV and are also shared. Moreover, as indicated by HSAs, these supplements are the only contribution that most PLHIV can make to their households. Sharing emerged as socially necessary and as a common practice. When exploring among HSAs potential strategies to avoid or limit the sharing of supplements with other household members, they indicated that packing supplements in individual servings and distributing them as part of the ART treatment (i.e. on a monthly basis) may reduce or limit sharing.

Theme 6: HSAs and family members may influence PLHIV dietary behaviors

We found that the nutritional counseling provided at the clinic influences the eating habits of PLHIV. When a person is diagnosed with HIV, the doctor requests that he or she attends the clinic with a family member, referred to as the 'guardian'. Together, PLHIV and guardians receive nutritional counseling once a month during health checks and treatment delivery. The nutritional counseling reinforces the benefits of consuming nsima/porridge, tubers, groundnuts, vegetables, fruits and small fish. A male participant with BMI <18.5 indicated:

'*...I had to learn to eat vegetables because the doctor told me that I should eat them because of the vitamins that help to fight the virus ...and my wife... she forces me to eat the relish* (common term to describe foods served together with nsima) *when I only want to eat nsima...*'

In addition, HSAs explained that PLHIV are aware of the frailty of their health and that this encourages them to adopt healthy eating habits. Most participants expressed that following the nutritional advice helps to improve their health. Some PLHIV indicated that they feel stronger and that they get sick less frequently when they eat as the HSAs advice. However, the majority of PLHIV indicated that following the advice provided at the clinic is not always possible because some days, food is simply not available. HSAs highlighted the role of

'guardians' in supporting healthy eating habits in the household. However, they indicated that although they think that their advice is important to foster healthy eating habits, some PLHIV cannot follow it because they cannot afford the foods recommended. They also indicated that family support varies among families and that the guardians do not always support the PLHIV in the household.

DISCUSSION

Several studies have focused on comparing the acceptance and efficacy of CSB and RUTF among adult PLHIV (Bahwere et al., 2009; M. Manary et al., 2010; Ndekha et al., 2009; van Oosterhout et al., 2010). RUTF shows promising results in achieving a more prompt restoration of BMI (L. Ahoua et al., 2011; Ndekha et al., 2009) and fat-free mass (Ndekha et al., 2009), and is increasingly being used in nutrition supplementation programs (M. F. Olsen et al., 2013). However, increasing evidence shows that the acceptance of RUTF is low among adult PLHIV (L. Ahoua et al., 2011; F. Dibari, P. Bahwere, et al., 2012). This study contributes to a better understanding of the factors that influence preferences for food and nutritional supplements, and provides information about the eating habits of PLHIV, to inform guidelines for the development of alternative nutritional supplements that could better fit PLHIV's cultural preferences for food and specific needs.

We identified preferences for soft textures and subtle, natural flavors like those from nsima, porridge, parboiled vegetables or cooked sweet potatoes. All participants, independent of their health challenges, indicated preference for small portions of food with soft, semi-liquid and liquid consistencies that can be eaten at different times throughout the day. In accordance with Dibari and colleagues (F. Dibari, P. Bahwere, et al., 2012), we found that strong flavors are disliked and that health challenges associated with HIV do affect food intake. We also found that spices, sugar, salt and fat are used sparsely and that food with hard textures and strong scents are disliked. Interestingly, the consumption of sour flavors was common among all participants, even by those suffering from mouth sores. The consumption of sour flavors was linked to the local cultural belief that sour foods and drinks help to restore health. Other studies have shown that cultural beliefs as well as cultural preferences for food are strong determinants of eating behaviors (L. Cantarero, Espeitx, Gil Lacruz, & Martin, 2012; Nestle et al., 1998; Rozin & Vollmecke, 1986b; Story, Neumark-Sztainer, & French, 2002), highlighting that these are cultural elements that need to be considered when developing nutritional supplements.

In accordance with Olsen (M. F. Olsen et al., 2013), we found that participants regarded their diets as insufficient and in need of improvement which offers an excellent opportunity to introduce nutritional supplements that complement the existing diet. In low-income settings, food insecurity affects a big proportion of PLHIV. In Malawi, an estimated 64% of people is food insecure (Harrigan, 2008). Among our participants, 22 out of 24 were unemployed and relied exclusively on the income of family members for food access and indicated that there was insufficient food for all household members. In this context, like in other food insecure environments, food is shared. We found that the potential nutritional supplements were perceived to be food by the majority of participants and therefore, if well accepted, they might be also shared as any other food. Sharing of supplements in food insecure settings has also been indicated by Olsen, Dibari, and Kebede (F. Dibari, P. Bahwere, et al., 2012; M. A. Kebede & J. Haidar, 2014; M. F. Olsen et al., 2013), which suggests the need to revise the approach to food assistance for PLHIV in food insecure settings. It would be worth exploring whether combining the distribution of the special nutritious food for PLHIV with household food assistance for food insecure households, whether in the form of food, cash or vouchers, reduces the sharing of the nutritional supplement.

Such an approach would be comparable to the distribution of special nutritious foods to young children for the prevention of acute malnutrition while at the same time providing food assistance to households that need it (R. G. Saskia de Pee, Bridget Fenn, Rebecca Brown, André Briend, Jacqueline Frize, Jeremy Shoham, and Lynnda Kiess, 2015). This approach is in-line with programming guidance of WFP as well as with the President's Emergency Plan for AIDS Relief, United States Agency for International Development (PEPFAR, USAID) (World Food Programme, 2014). Counseling activities in health care facilities and/or integrated in safety net programs can also contribute to prevent sharing and increase adherence to product use as prescribed (Frega et al., 2010). The importance of integrating nutrition programming in the standard care of PLHIV to relieve food insecurity, improve their nutritional status and overall health has been also underscored by other authors (Dibari, Diop el, Collins, & Seal, 2012; Frega et al., 2010; Rawat, Faust, Maluccio, & Kadiyala, 2014).

Other strategies used to improve adherence of ART applied in sub-Saharan African countries might also work in fostering a compliant use of nutritional supplements and preventing sharing among PLHIV in Malawi. Treatment supporters with directly observed therapy, and mobile-phone text messages to remind daily intake of pills have shown to be effective, for example (Barnighausen, Kyle, Salomon, & Waning, 2012).

In this setting, a nutritional supplement of thick liquid consistency possessing slightly sweet and sour flavors may be highly accepted. If packed in personal servings and delivered together with family rations of staple foods, such supplements might also be minimally shared. Key messages, based on formative research, tailored to foster a compliant daily use of full individual servings of the product may help to promote adherence to its use. Our results indicate that a packet including images depicting the content inside the package, a list of ingredients, best-use-before date, and brand may contribute to improve product acceptability. Our results also show that package information should be written in the local language i.e. Chichewa for Malawi, to help users understand the information conveyed by the packet.

Limitations and strengths

The sample of this study belongs to groups of PLHIV and HSA who live in rural communities located in the surrounding areas of Blantyre and who access the Chilomoni clinic in Chilomoni. Perceptions and experiences of PLHIV and HSAs living in different regions of Malawi may differ. However, the findings of this study are consistent across different sources of information (PLHIV and HSAs), genders (male and female) and are consistent with findings of studies from other African countries (L. Ahoua et al., 2011; F. Dibari, P. Bahwere, et al., 2012; M. F. Olsen et al., 2013). Participants' responses to some topics, particularly the positive influence of eating behaviors attributed to counseling sessions imparted by HSAs, and food habits, might have been biased, due to a social desirability, especially because the IDIs were conducted at the Chilomoni clinic.

Another limitation of this study is related to translation. During translation the meaning of some segments of the data might have been lost. To minimize loss of meaning, we trained data collectors to enquire deeply into PLHIV's preferences for food in relation to HIV and associated diseases. In addition, we collected rich contextual information related to the community settings, relations with family members, friends, neighbors, as well as information related to cultural eating practices and common preferences for foods and drinks in the general population. The contextual information allowed us to better understand the experiences of PLHIV with food within their sociocultural context. Furthermore, transcriptions and translations were made verbatim, which contributed to preserving the statements of participants as they were communicated. Expressions that were not possible to meaningfully translate into English were kept in Chichewa and explained in English by data collectors for a better interpretation during data analysis. These steps contributed to preserving the original meaning of the data, thereby minimizing data loss (John W. Creswell & Creswell, 2013; Patton, 2002b; van Nes, Abma, Jonsson, & Deeg, 2010).

CONCLUSIONS

This study highlights the need to consider PLHIV's food preferences, health challenges and food insecurity in the household during the development of nutritional supplements. In this setting, a thickened liquid supplement, slightly sweet and sour, packed in personal single serving packaging may be well-accepted and when complemented with household food assistance for food insecure households, may be minimally shared. A combination of descriptive and affective sensorial tests should follow to fine-tune the organoleptic characteristics of the product to the taste and requirements of PLHIV. Results of this study may be transferable to settings with similar cultures and food preferences.

References

Rodriguez, M. (2011). Nutrition outcomes of HIV-infected malnourished adults treated with ready-to-use therapeutic food in sub-Saharan Africa: a longitudinal study. *J Int AIDS Soc, 14*, 2. doi:10.1186/1758-2652-14-2

Anema, A., Vogenthaler, N., Frongillo, E. A., Kadiyala, S., & Weiser, S. D. (2009). Food insecurity and HIV/AIDS: current knowledge, gaps, and research priorities. *Curr HIV/AIDS Rep, 6*(4), 224-231.

Bahwere, P., Sadler, K., & Collins, S. (2009). Acceptability and effectiveness of chickpea sesame-based ready-to-use therapeutic food in malnourished HIV-positive adults. *Patient Prefer Adherence, 3*, 67-75.

Barnighausen, T., Kyle, M., Salomon, J. A., & Waning, B. (2012). Assessing the population health impact of market interventions to improve access to antiretroviral treatment. *Health Policy and Planning, 27*(6), 467-476. doi:DOI 10.1093/heapol/czr058

Berhe, N., Tegabu, D., & Alemayehu, M. (2013). Effect of nutritional factors on adherence to antiretroviral therapy among HIV-infected adults: a case control study in Northern Ethiopia. *BMC Infect Dis, 13*, 233. doi:10.1186/1471-2334-13-233

Bloem, M. W., & Saadeh, R. (2010). Foreword: The role of nutrition and food insecurity in HIV and tuberculosis infections and the implications for interventions in resource-limited settings. *Food and nutrition bulletin, 31*(4), S289-S291.

Cantarero, L., Espeitx, E., Gil Lacruz, M., & Martin, P. (2012). Human food preferences and cultural identity: The case of Aragon (Spain). *Int J Psychol*. doi:10.1080/00207594.2012.692792

Creswell, J. W., & Creswell, J. W. (2013). *Qualitative inquiry and research design : choosing among five approaches* (3rd ed.). Los Angeles: SAGE Publications.

de Pee, S., & Semba, R. D. (2010). Role of nutrition in HIV infection: review of evidence for more effective programming in resource-limited settings. *Food and nutrition bulletin, 31*(4), S313-344.

Dibari, F., Bahwere, P., Le Gall, I., Guerrero, S., Mwaniki, D., & Seal, A. (2012). A qualitative investigation of adherence to nutritional therapy in malnourished adult AIDS patients in Kenya. *Public Health Nutr, 15*(2), 316-323. doi:10.1017/S1368980010003435

Dibari, F., Diop el, H. I., Collins, S., & Seal, A. (2012). Low-cost, ready-to-use therapeutic foods can be designed using locally available commodities with the aid of linear programming. *J Nutr, 142*(5), 955-961. doi:10.3945/jn.111.156943

Frega, R., Duffy, F., Rawat, R., & Grede, N. (2010). Food insecurity in the context of HIV/AIDS: a framework for a new era of programming. *Food and nutrition bulletin, 31*(4), S292-312.

Harrigan, J. (2008). Food insecurity, poverty and the Malawian Starter Pack: Fresh start or false start? *Food Policy, 33*, 237-249. doi:10.1016

Kebede, M. A., & Haidar, J. (2014). Factors influencing adherence to the food by prescription program among adult HIV positive patients in Addis Ababa, Ethiopia: a facility-based, cross-sectional study. *Infect Dis Poverty, 3*, 20. doi:10.1186/2049-9957-3-20

Koethe, J. R., Chi, B. H., Megazzini, K. M., Heimburger, D. C., & Stringer, J. S. A. (2009). Macronutrient Supplementation for Malnourished HIV-Infected Adults: A Review of the Evidence in Resource-Adequate and Resource-Constrained Settings. *Clinical Infectious Diseases, 49*(5), 787-798. doi:Doi 10.1086/605285

Macallan, D. C. (1999). Malnutrition in tuberculosis. *Diagn Microbiol Infect Dis, 34*(2), 153-157.

Manary, M., Ndekha, M., & van Oosterhout, J. J. (2010). Supplementary feeding in the care of the wasted HIV infected patient. *Malawi Medical Journal, 22*(2), 46-48.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative data analysis : a methods sourcebook* (Third edition. ed.). Thousand Oaks, Californinia: SAGE Publications, Inc.

Ministry of Health, G. (March 2006). *Interim Guidelines for the management of acute malnutrition in adolescents and adults*. Malawi: Ministry of Health, Government of Malawi

Ndekha, M. J., van Oosterhout, J. J., Zijlstra, E. E., Manary, M., Saloojee, H., & Manary, M. J. (2009). Supplementary feeding with either ready-to-use fortified spread or corn-soy blend in wasted adults starting antiretroviral therapy in Malawi: randomised, investigator blinded, controlled trial. *BMJ, 338*, b1867. doi:10.1136/bmj.b1867

Nestle, M., Wing, R., Birch, L., DiSogra, L., Drewnowski, A., Middleton, S., . . . Economos, C. (1998). Behavioral and social influences on food choice. *Nutr Rev, 56*(5 Pt 2), S50-64; discussion S64-74.

Olsen, M. F., Tesfaye, M., Kaestel, P., Friis, H., & Holm, L. (2013). Use, perceptions, and acceptability of a ready-to-use supplementary food among adult HIV patients initiating antiretroviral treatment: a qualitative study in Ethiopia. *Patient Prefer Adherence, 7*, 481-488. doi:10.2147/PPA.S44413

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3 ed.). Thousand Oaks, Calif.: Sage Publications.

Rawat, R., Faust, E., Maluccio, J. A., & Kadiyala, S. (2014). The impact of a food assistance program on nutritional status, disease progression, and food security among people living with HIV in Uganda. *J Acquir Immune Defic Syndr, 66*(1), e15-22. doi:10.1097/QAI.0000000000000079

Rollins, N. (2007). Food insecurity--a risk factor for HIV infection. *PLoS Med, 4*(10), 1576-1577. doi:10.1371/journal.pmed.0040301

Rozin, P., & Vollmecke, T. A. (1986). Food likes and dislikes. *Annual review of nutrition, 6*, 433-456.

Sandelowski, M. (2000). Combining qualitative and quantitative sampling, data collection, and analysis techniques in mixed-method studies. *Res Nurs Health, 23*(3), 246-255.

Saskia de Pee, R. G., Bridget Fenn, Rebecca Brown, André Briend, Jacqueline Frize, Jeremy Shoham, and Lynnda Kiess. (2015). Prevention of acute malnutrition: Distribution of special nutritious foods and cash, and addressing underlying causes—what to recommend when, where,for whom, and how. *Food and nutrition bulletin, 36*(1), 25-30.

Semba, R. D., Darnton-Hill, I., & de Pee, S. (2010). Addressing tuberculosis in the context of malnutrition and HIV coinfection. *Food and nutrition bulletin, 31*(4), S345-364.

Story, M., Neumark-Sztainer, D., & French, S. (2002). Individual and environmental influences on adolescent eating behaviors. *J Am Diet Assoc, 102*(3 Suppl), S40-51.

Teddlie, C., & Yu, F. (2007). Mixed Methods Sampling A Typology With Examples. *Journal of Mixed Methods Research, 1*(1), 77-100. doi:Doi 10.1177/2345678906292430

Tiyou, A., Belachew, T., Alemseged, F., & Biadgilign, S. (2012). Food insecurity and associated factors among HIV-infected individuals receiving highly active antiretroviral therapy in Jimma zone Southwest Ethiopia. *Nutr J, 11*, 51. doi:10.1186/1475-2891-11-51

UNAIDS. (2010). *Global report: UNAIDS report on the global AIDS epidemic 2010*. Geneva: UNAIDS.

van Nes, F., Abma, T., Jonsson, H., & Deeg, D. (2010). Language differences in qualitative research: is meaning lost in translation? *Eur J Ageing, 7*(4), 313-316. doi:10.1007/s10433-010-0168-y

van Oosterhout, J. J., Ndekha, M., Moore, E., Kumwenda, J. J., Zijlstra, E. E., & Manary, M. (2010). The benefit of supplementary feeding for wasted Malawian adults initiating ART. *AIDS Care, 22*(6), 737-742. doi:10.1080/09540120903373581

Wanke, C., & Kotler, D. (2004). Collaborative recommendations: the approach to diagnosis and treatment of HIV wasting. *J Acquir Immune Defic Syndr, 37 Suppl 5*, S284-288.

World Food Programme, P. s. E. P. f. A. R., United States Agency for International Development, UNAIDS. (2014). Nutrition assessment, counselling and support for adolescents and adults living with HIV a programming guide *FOOD AND NUTRITION IN THE CONTEXT OF HIV AND TB*. Geneva, Switzerland.

Chapter 3

Psychosocial factors influencing preferences for food and nutrient supplements among people living with HIV (PLHIV) in Bangkok, Thailand

Santiago Rodas-Moya
Supabhorn Pengnonyang
Stephen Kodish
Saskia de Pee
Praphan Phanuphak

Published (Appetite Journal)

ABSTRACT

Malnutrition and HIV are often coincident and may lead to wasting, a strong predictor of mortality. However; ready to use therapeutic foods (RUTF) are showing promising results in restoring the nutritional status of adult people living with HIV (PLHIV) in resource constrained settings; but, its acceptability seems low. This study aimed to identify the psychosocial factors influencing general preferences for food and responses to five potential nutritional supplements to guide the development of novel products to treat malnutrition among PLHIV. This is a qualitative research based on Grounded Theory. In-depth interviews (IDIs) with a triangulation of data from different participants (i.e. PLHIV and Peer Counselors (PCs) were used as methods for data collection. During February-March 2013, 27 IDIs were conducted in the Anonymous Clinic of the Thai Red Cross and AIDS Research Centre in Bangkok, Thailand. Five themes emerged: 1) local food culture is an important motive underlying the nutritional supplements choice by PLHIV; 2) food and drinks should have self-perceptible positive impact on health status and should be perceived convenient; 3) a soft and easy to swallow texture, softer scents and flavors are the major sensory characteristics guiding food and beverages choice; 4) food packaging characteristics affect nutritional supplement preference; 5) PCs may support nutritional supplement consumption. Similar findings emerged among PLHIV and PCs. This study highlights the need to develop a nutritional supplement considering the Thai culture and PLHIV's sensory preferences. A slightly thick liquid supplement, packed in small containers may be well-accepted. A combination of sensory studies and formative research should accompany the development of an alternative nutritional supplement for PLHIV. Results of this study might be transferable to similar sociocultural contexts.

INTRODUCTION

An estimated 445,500 people aged 15 to 49 years are living with HIV in Thailand (UNAIDS, 2015). Thailand is among the 11 countries in the Asia-Pacific region bearing the majority of people living with HIV (PLHIV) (UNAIDS, 2015). HIV disproportionately affects specific vulnerable groups, i.e. men who have sex with men, transgendered people, male and female sex workers, people who inject drugs and discordant couples (UNAIDS, 2015).

HIV infection leads to malnutrition, which itself has a significant detrimental impact on HIV outcomes (Duggal, Chugh, & Duggal, 2012) and is a strong and independent risk factor for mortality (Argemi et al., 2012). When untreated, HIV status and undernutrition result in severe impaired metabolic functions in absorption, storage, and utilization of nutrients, as well as in an exacerbation of the catabolic nature of HIV infection (Ivers et al., 2009). These conditions lead to the HIV wasting syndrome, which has long been established as a strong predictor of mortality in PLHIV (Tang, 2003). HIV-associated wasting, in most cases, results from a combination of factors, including HIV infection, opportunistic infections, anorexia and medications (Diouf et al., 2016). Furthermore, malnourished PLHIV have a higher risk of death and suboptimal response to treatment, especially at the start of anti-retroviral therapy (ART) (S. de Pee & R. D. Semba, 2010).

Because PLHIV are at high risk of malnutrition, nutritional care and support is an important way to improve ART outcomes and overall health of PLHIV (World Food Programme (WFP)., UNAIDS)., & U.S. President's Emergency Plan for AIDS Relief (PEPFAR). 2014). Evidence suggests that increases in net daily energy and macronutrient intake can be achieved with oral dietary supplements, and their use may be an effective means of maintaining or increasing caloric intake for PLHIV (Grinspoon et al., 2003). Micronutrient content should be such that PLHIV achieve at least one Recommended Nutrient Intake (RNI) (S. de Pee & R. D. Semba, 2010; Forrester & Sztam, 2011a).

Likewise, when PLHIV are on ART, numerous studies show that administering nutritional supplements together with ART results in better tolerance and greater adherence to treatment, reduction in hunger, weight gain, improvement in immune function, and increased levels of physical activity (L. Ahoua et al., 2011; Bahwere et al., 2009; Berhe et al., 2013; Byron, Gillespie, & Nangami, 2008; D. Evans et al., 2013).

In low-income countries, supplementary feeding in the form of corn-soy blend (CSB) or ready-to-use therapeutic food (RUTF) is habitually used to treat malnourished adult PLHIV (BMI < 18.5 kg/m2) (S. de Pee & R. D. Semba,

2010). Although RUTF was originally developed to treat acute malnutrition in children, it is now being increasingly used by international organizations and non-governmental organizations to treat malnutrition in adult PLHIV (M. F. Olsen et al., 2013). For a successful nutritional rehabilitation, RUTF should be consumed in amounts of up to ~500 g (~2675 kcal) per day (Ndekha et al., 2009) for a period of 3-4 months along with ART initiation (M. A. Kebede & J. Haidar, 2014; Ndekha et al., 2009). When consuming RUTF as the main source of energy intake, the absolute intake of some nutrients, particularly iron, zinc and copper, is higher than the RNI for adults or the intake recommended for treating moderate acute malnutrition (S. de Pee & R. D. Semba, 2010).

Furthermore, sensorial attributes such as the RUTF's taste (e.g. too sweet and salty) and consistency (i.e. too oily) have been indicated to be barriers to its acceptability (F. Dibari, P. Bahwere, et al., 2012; M. A. Kebede & J. Haidar, 2014). Poor knowledge on RUTF benefits, the recommended period of consumption (e.g. 3-4 months), as well as the high daily prescribed RUTF amount have also been reported to make it difficult for PLHIV to comply with the prescribed intake (M. A. Kebede & J. Haidar, 2014). Sharing the RUTF with non-beneficiaries (M. A. Kebede & J. Haidar, 2014; M. F. Olsen et al., 2013) or putting it on sale for replacement with other food items also results in lower intake by adult PLHIV than what is recommended (M. A. Kebede & J. Haidar, 2014). Moreover, Health challenges, such as nausea, vomiting, diarrhea, and lack of appetite, have been indicated as potential barriers to the acceptance and adherence to RUTF (F. Dibari, P. Bahwere, et al., 2012; M. F. Olsen et al., 2013; S. Rodas-Moya, Kodish, Manary, Grede, & de Pee, 2015).

Although several aspects that affect the RUTF consumption have been identified, there is little evidence of psychosocial factors that influence the acceptance and adherence to nutritional supplements. According to the Social Cognitive Theory (SCT), psychosocial factors are a set of individual and socio-structural determinants, as well as several mechanisms through which they work to regulate motivation and human behavior within a specific social-cultural context (Bandura, 2002, 2004).

This study aimed to identify the psychosocial factors influencing general preferences for food and responses to five potential nutritional supplements to guide the development of novel products to treat malnutrition among adult PLHIV in Bangkok, Thailand.

METHODS

Approach

The study design is based on Grounded Theory, an inductive, comparative, emergent, and open-ended methodology (Charmaz, 2014). This theory is particularly useful for understanding and describing the particular psychosocial realities constructed by PLHIV when building their choices for food and nutritional supplements.

Sampling and study participants

The concept of data saturation was utilized to define the sample size of this study. Data saturation is reached when the data that are being collected do not provide new insights (Charmaz, 2014; John W. Creswell & Creswell, 2013; Patton, 2002b). Based on this concept, a sample size between twenty and thirty participants may constitute a sufficient sample size when Grounded Theory is used as background for data collection (Charmaz, 2014; John W. Creswell & Creswell, 2013; Patton, 2002b).

The present study was conducted during February and March 2013, in the Anonymous Clinic of the Thai Red Cross AIDS Research Center (TRCARC) in Bangkok, Thailand. The study participants are PLHIV from both urban and rural Metropolitan Bangkok who attended the anonymous clinic for ART treatment or to verify their CD4 count. All participants were contacted by the nutritionist from the TRCARC, by phone or in-person during the follow up visits and were invited to participate in the study.

Participants were selected using a purposeful sampling approach (Patton, 2002a). The inclusion criteria were: male or female living with HIV, age range 18-49 years, BMI < 18.5 kg/m2 and receiving ART. Parameters of inclusion criteria were verified by the nutritionist of TRCARC.

To triangulate data sources (Patton, 2002b; Sandelowski, 2000), seven Peer Counselors (PCs) were included in the study. PCs are volunteer workers of the TRCARC who have been diagnosed as HIV positive and have been enrolled on ART for some years. PCs have rich knowledge about PLHIV's health challenges and experiences with food, and thus they were considered key informants who could talk not only about themselves, but also about other PLHIV (Charmaz, 2014). In total, 27 interviews were conducted. All participants were recruited by the health care personnel of the Anonymous Clinic of TRCARC in Bangkok, Thailand.

Potential nutritional supplements

To investigate perceptions toward potential nutritional supplements, five products were included: cream filled chocolate cereals (~2.5 cm X 2.5 cm pillow shaped, hard crunchy texture outside soft chocolate filling inside), fruit bars (~6 cm X 3 cm dark brown bars of a soft consistency, sweet and sour flavors made with citric fruits and peanuts), Krayasat (~14 cm X 4.7 cm local snack made with peanuts, sesame seeds and honey, soft sticky texture, slight crunchy), instant noodles (70 g of medium spicy instant noodles with dried ground pork that need to be mixed with hot water and eaten like soup) and 80 ml of local yogurt drink of slightly sweet and sour orange flavor. Energy and nutrient densities of these products could potentially be adjusted to meet the requirements for supplements for treating malnutrition i.e. 300-500 kcal/100 g of product ready for consumption and approximately 1 RNI of micronutrients per 100 g.

Samples of the cream-filled cereals were packed by the manufacturer in plastic containers of ~500 g and were re-packed by researchers in plastic zip-lock bags containing eight units. The fruit bars were packed by the manufacturer in individual white soft plastic wrapping material and showed an expiration date. The Krayasat were packaged by an artisanal manufacturer in translucent soft plastic wrapping material without expiration date. The yogurt drink and the instant noodles were commercially available, packed by the manufacturers in an 80 ml tetra pack container and in paper based cups laminated with polyethylene containing 70 g of dry product, respectively.

The cream filled chocolate cereals and fruit bars were selected because we were interested in a portfolio of easy to carry and easy to consume products at different times during the day. They are also easy to distribute at clinics and in food assistance programs at community level. The Krayasat and instant noodles were included because they have the same aforementioned characteristics and because we were interested in exploring differences in acceptability between local and western products. The yogurt drink was included because in a similar study conducted in Malawi, preferences toward nutritional supplements in liquid form emerged among the majority of PLHIV (S. Rodas-Moya et al., 2016).

Ethical procedures

The Institutional Review Board from the Faculty of Medicine from the Chulalongkorn University of Thailand and the Institutional Review Board of Wageningen University in The Netherlands, granted permission for conducting this study. All participants provided written informed consent and were told that

they could ask questions about the study. PLHIV and PCs were compensated with 500 Thai Baht (~US$ 16) which included food and transportation fees.

Anthropometric data collection

Anthropometric measurements were performed by a professional investigator using the procedures recommended by Preedy (Preedy, 2012). Weight was measured to the nearest 0.1 kg, without shoes and heavy outer clothing. Height was measured to the nearest 0.1 cm with participant standing barefoot upright on a platform with eyes on the Frankfort plane. The Body Mass Index (BMI) was calculated to assess nutritional status as weight divided by the square of the height (kg/m2). Participants with BMI <18.5 were considered underweight.

Qualitative data collection

Qualitative, in-depth interviews (IDIs) were used as method of data collection. A data collection team of four bilingual Thai-English nutritionists was trained for 40 hours on in-depth interviewing techniques by the principal investigator. Semi-structured interview guides were developed with major questions, which were then followed by a sequence of sub-questions and suggested probes.

The semi-structured interview guides were developed in English. The IDI guides were then translated into Thai by the data collectors. To ensure accuracy of translation, IDI guides were back translated from Thai into English by a professional translator who was fluent in Thai and English. The interview guides were field tested for understanding with people of similar socioeconomic characteristics to the study population prior to data collection. A second set of adjustments were made to the guides and questions that were unclear during that field test.

The interviews were designed to explore the cultural preferences of PLHIV for food i.e. preferences determined by tradition including methods of preparation, flavoring specific combinations of foods and the appropriate time to consume them during the day (Rozin & Vollmecke, 1986a). The interviews were also designed to explore possible psychosocial factors that influence food preferences, and the perceived barriers and enablers to the acceptance of five potential nutritional supplements. Examples of questions asked to explore the different topics are presented in Table 3.1.

Table 3.1. Examples of questions asked to explore the factors that influence preferences for food and nutritional supplements among PLHIV in Bangkok, Thailand.

Questions to explore food preferences include:
• Thinking of a typical week, what are the meals that you usually eat?
> Which of these meals is your favorite?
> How is this meal prepared?
> What makes this meal your favorite meal?
- Probe into reasons for liking
• What kind of foods do you dislike?
> Are there specific ingredients that you don't like?
- Probe into reasons for disliking
Questions to identify the factors that influence preferences for foods include:
• Did your likings for food change after you were diagnosed with HIV?
• What made you change your former preferences for food?
> Are there foods that you prefer to consume now and that you didn't consume before?
> What makes you choose these foods?
- One by one, probe into types of foods, textures, flavors and scents
Questions to explore perceptions toward the 5 potential nutritional supplements include:
• Here is one of the products that we want to evaluate with you:
> Look at the product and tell me what comes to your mind when you see this product.
> Please smell the product. What do you think about its smell?
> Please try the product.
- Probe into perceptions about general appearance, color and consistency
- Probe into perceptions about taste
- Probe into perceptions about consistency

All participants were requested not to smoke, eat or drink anything other than water for at least 1 hour before tasting the food samples (Brown, 2008). PCs and PLHIV were asked the same questions.

Each data collector conducted and transcribed two interviews per week. Translations were made immediately after transcripts were delivered to the professional translator. This procedure allowed the main researcher ample time for data immersion, analyses and subsequent interview planning (Charmaz, 2006). Data collection followed an iterative approach until data saturation was reached (Charmaz, 2006). Each interview lasted on average 75 minutes. Interviews were conducted one-on-one in a quiet room at the TRCARC Anonymous Clinic over a six-week period. Twenty PLHIV were interviewed.

To contrast patterns and explanations emerging from the textual data, two deviant cases were identified among the 20 PLHIV (Patton, 2002b). The

deviant cases were two participants who did not fit the profile of the majority of PLHIV included in the sample. One of these participants belonged to the fourth economic quintile and had completed university, whereas the other participants belonged to the first and second economic quintiles. The other person was a female PLHIV from Cambodia, married to a Thai man. Deviant cases contributed to identify exceptions to general opinions and strengthened theory building during analysis (Charmaz, 2014; Patton, 2002b).

To collect information on gender, age, income, and educational level, a socio-demographic questionnaire was administered to PLHIV at the end of each interview.

Data analysis

Throughout data collection, digital recordings were transcribed and translated verbatim from Thai into English to ensure local language meanings were retained during the process. First, the interviews were read several times by the principal investigator to form a holistic view of the data. Data analysis followed procedures suggested by Miles, Huberman and Saldaña (Matthew B. Miles et al., 2014).

To facilitate analysis, a list of codes was developed that served as a framework of analysis. Twenty-three categories of information (codes) were initially developed to form the list. These codes were applied to paragraphs of text to summarize segments of data (first cycle coding). Through second cycle coding, the 23 codes were then clustered and merged into 10 pattern codes (Matthew B. Miles et al., 2014). Interrelations between pattern codes were then examined and five main categories (themes) were subtracted for theory building (Matthew B. Miles et al., 2014). A crossed comparison of the coded passages was conducted between the two data sources: PLHIV (n=20) and PCs (n=7). Data from the two deviant cases that did not fit the dominant patterns were utilized to examine divergences and add detail to descriptions and overall theory.

Data were analyzed in Atlas ti v.7.09 (John W. Creswell & Creswell, 2013; Matthew B. Miles et al., 2014). Exemplar quotations that best described PLHIV's experiences were used to illustrate findings. Results were corroborated (John W. Creswell & Creswell, 2013; Matthew B. Miles et al., 2014; Patton, 2002b) with PCs and the health care personnel of the TRCARC anonymous clinic.

RESULTS

The BMI and demographic characteristics of PLHIV participants are presented in Table 3.2.

Table 3.2. BMI and demographic characteristics of PLHIV

Characteristics of participants		**No. of participants**
BMI	Undernourished (BMI < 18.5 kg/m2)	20
Age range, mean and SD[1]	18-49 years (Mean age = 41.3; SD = 6.6)	20
Gender	Male	11
	Female	9
Education	Completed primary school	6
	Completed secondary school	8
	More than secondary school	6
Monthly Income THB[2]	0 - 9999	12
	10000 – 29999	7
	30000 – 49999	0
	50000 – 69000	1

[1]Standard Deviation

[2]THB = Thai Bath (Exchange rate when conducting the study: US$ 1 = 31.25 THB)

Emerging themes

Data are presented according to emergent themes, supported by quotes that illustrate the responses that PLHIV and PCs gave for specific issues. Five major themes emerged from the data.

Theme 1: Local food culture is an important motive underlying the nutritional supplements choice by PLHIV

The daily variety in the selection of meals emerged as a strong element of the Thai food culture. Meals are prepared with a wide variety of sauces and herbs that result in an artful combination of colors, smells, flavors and textures. Therefore, the participants' discourse focused on these food characteristics. Variety, familiarity with the product, flavor, textures and colors were the main characteristics of the potential nutritional supplements discussed by participants. Table 3.3 presents a summary of the perceptions that emerged as factors that influence the acceptability of the explored products among PLHIV.

Table 3.3. Summary of perceptions about the 5 potential nutritional supplements among PLHIV

Cream filled chocolate cereals **(2.5 cm X 2.5 cm pillow shaped hard crunchy texture outside soft chocolate filling inside)**
3.3.1. 'This is Western food. Its smell and how it looks like is unfamiliar and unappetizing.'
3.3.2. 'We, Thais, eat meals with natural colors; this is not cheerful.... More cheerful colors would make it more appetizing.'
Fruit bars (6 cm X 3 cm dark brown bar of a soft consistency, **sweet and sour flavors made with citric fruits and peanuts)**
3.3.3. 'It is a foreign product. I can't tell what it is... .' 'I don't like it. It looks like chocolate, but when you smell it... mmm wait... it is like an unusual mixture of many things and it is brownish... unappetizing.'
Krayasat (14 cm X 4.7 cm local snack made with peanuts, sesame seeds and honey. **Soft sticky texture, slightly crunchy)**
3.3.4. 'This is Krayasat. It reminds me of my youth. When I was a kid I used to enjoy Krayasat...'
3.3.5. 'This is a Thai snack. You can see it in its ingredients. It has sesame seeds, nuts. Its colors are natural and appetizing, but it's not for eating every day. It has too much sugar and it's chewy.'
Medium spicy instant noodles **(70 g cup with dried ground pork. It's mixed with hot water and eaten like soup)**
3.3.6. 'Those are instant noodles. The flavor is just right, not too strong, or spicy, easy to fix and convenient, but I would not eat it... It is for the low in cash ε or when there is flooding.'
Local drinking yogurt of sweet and slightly sour orange flavor packed in an 80 ml container
3.3.7. 'I know this product. Typical color of drinking yogurt.... It is good. Not too sour or sweet. Not smelly.... It has an orange smell. I like oranges, I like this smell.'

As shown in table 3.3., local products were partially well accepted. The Krayasat and the yogurt drink (local products) elicited positive responses. However, when exploring perceptions about the instant noodles, despite acceptance of its sensory characteristics, they were perceived to be food for people of low income and for distribution in emergencies. Hence, this food had a low social value. The majority of participants indicated: 'these noodles are food for the low in cash.' Some participants said: 'the instant noodles are used during emergencies, such as the flood season.' Thus, the instant noodles were also largely rejected because they were regarded as food for resource-constrained people. No differences emerged between perceptions of PLHIV and PCs.

The fruit bar and the chocolate cereals were perceived to be unfamiliar, unappetizing and unrelated to the Thai food culture. Their ingredients, colors and textures were disliked by all of the participants.

Unanimously, PC indicated that the chocolate cereals and fruit bars would be rejected because they would be perceived to be a 'strange food' and because of their smell, color and chewy texture. A participant indicated:

'PLHIV would not like these foods. They seem strange... If they chew these foods for a long time, especially a tough food like these two things (referring to cereals and fruit bar) they will feel tired. From my experiences, I used to be like that, and I would not eat these foods... This fruit bar... Are there fruits in there? It looks like a color contamination...'

Peer Counselor, female, Bangkok.

Theme 2: Food and drinks should have self-perceptible positive impact on health and should be perceived convenient.

Consistently, participants indicated that food is important to maintain health and strength (Table 3.4.).

Table 3.4. Perceived effects of food on PLHIV's health

3.4.1.	'Vegetables for instance give vitamins to fight diseases, they are easy to chew and swallow and they also help with bowel movements.'
3.4.2.	'All fruits except durian are beneficial. They have vitamins and prevent constipation. If I eat fruits, I won't feel that tired.'
3.4.3.	'I like to eat rice... it gives energy.'
3.4.4.	'Fish has proteins. It's good for gaining muscle in arms and legs. It makes you look healthy. Thais love fish. I eat it almost in every meal, because it is easy to fix, it's tender and delicious.'
3.4.5.	'Soy milk or yogurt is good for PLHIV. They have proteins for building the body. Yogurt is also good to strengthen the bones.'
3.4.6.	Some foods like pla rah[1], som pla[2] and other fermented foods can give us a runny stomach, nausea and vomiting because of bacteria. Our immune system isn't good so we can't eat unhygienic food...'
3.4.7.	'The doughy and oily Westernized foods are bad for health. They make me feel stuffed...'
3.4.8.	'Foods that are bad for health are for instance curries made with a lot of fat, especially those made with coconut milk... pork with a lot of fat or fried fish.'
3.4.9.	Fat collects and blocks your blood vessels.'
3.4.10.	'ART makes PLHIV sensitive to heart disease and diabetes. I have to be careful with sweets, salt, fatty and doughy foods...'

[1] Fermented fish added with salt.

[2] Fermented fish added with salt and sticky rice of sour taste, both fried.

Foods such as fruits and vegetables were considered beneficial because they were perceived to prevent constipation. Participants also indicated that fruits and vegetables 'provide vitamins for strengthening the immune system, and energy for daily life activities' (Table 3.4., comments 3.4.1, 3.4.2). In addition, cooked (or sometimes fried) and leafy vegetables were unanimously perceived to be 'easy to chew and swallow,' a characteristic that all participants indicated they try to find when choosing foods to avoid becoming tired. Rice, fish (and other seafood), soy milk and yogurt were also perceived to provide energy, but most importantly to provide proteins to 'reshape the body' and other nutrients that contribute to improving health and providing a healthy appearance (Table 3.4., comments,3. 4.3-3.4.5).

The majority of participants voiced their concern about acquiring food-borne illnesses (e.g. diarrhea, nausea, vomiting). Hence, fermented foods such as pla rah (fermented fish with salt) or pla som (fermented fish with salt and sticky rice of sour taste) were perceived to be 'dangerous' and were avoided. These and other fermented foods were perceived to be a source of bacteria when they are not prepared with high hygienic standards (Table 3.4., comment 3.4.6). Furthermore, participants unanimously indicated being concerned about developing health problems related to the potential side effects of ART. Given the high concern about developing heart disease, hypertension, and diabetes, behavior geared towards the elimination of foods perceived to be excessively sweet, salty, doughy and fatty (Table 3.4, comments 3.4.7-3.4.10).

Perceived convenience also emerged as a key factor in the acceptability of food and nutritional supplements. PCs and PLHIV indicated that a food product is perceived to be convenient if it's 'easy to find or buy,' 'easy to prepare,' 'easy to carry,' 'affordable' and had a 'good quality vs price'.

Theme 3: A soft and easy to swallow texture, softer scents and flavors are the major sensory characteristics guiding food and beverages choice

Health challenges associated with HIV also influence preferences for food and drinks (Table 5).

Table 3.5. Main preference for textures and flavors and health challenges

3.5.1.	'We (PLHIV) get easily exhausted with very little effort. Sometimes I feel so tired that I don't feel like eating. I try to eat foods that are easy to chew, like fish, or bland soup. Drinks that can give me energy like Ovaltine (commercial brand of a thick chocolate drink).'
3.5.2.	'When I have diarrhea I feel so weak, and food isn't appetizing. Almost all kind of foods are heavy, so I try to eat small portions of congee[1], liang soup[2] or bland soup[3], foods that can give me some energy and help me to recover...'
3.5.3.	'I avoid very spicy foods and all bold flavors like sweet and sour sauces. I need drinks that refresh my mouth and calm thirst.'
3.5.4.	'The meds make the food taste weird. Food is less appetizing and it's hard to swallow. I eat fruits; I like oranges and strawberries because I can feel the sourness in my mouth and it relieves the aftertaste of the meds.'
3.5.5.	'The virus and the meds make us very sensitive to the strong flavors. For instance, we still enjoy sour and spicy foods, but they need to be less bold...'

[1] Thick rice porridge or gruel served as side dish. It can be served with meats and vegetables. It's commonly used in periods of disease.
[2] Soup with assorted vegetables. Prawns can be added.
[3] Thick white soup made with chicken or pork broth. Some tofu and vegetables can be added.

Preference for foods of soft texture and thick-liquid drinks emerged as a commonality among all PLHIV, independent of the health challenges that affected them. Fatigue and lack of appetite, both attributed to ART, HIV infection and the presence of episodic diseases, were the main drivers to search for foods of soft or liquid consistencies. Such foods are perceived to be easy to chew and swallow (Table 3.5, comment 3.5.1), and thus suitable for consumption when weak or ill. The presence of diarrhea was linked to preferences for foods that are perceived as 'light' or 'easy to digest' and 'easy to chew,' which were also foods of soft textures and liquid-thick consistencies (Table 3.5., comment 3.5.2). A preference for subtle savory and slightly salty flavors was indicated by the majority of participants when having diarrhea (Table 3.5., comments 3.5.2, 3.5.3).

Consistently, participants indicated that ART negatively affects their ability to taste food. Consumption of citrus fruits such as oranges and strawberries were indicated because they help to relieve the after taste of medicines and

release a pleasant sour flavor in the mouth (Table 3.5., comment 3.5.4). The majority of participants indicated having taste disturbances and developing sensitivities to some flavors. Notably, this resulted in general preferences for less bold sour and spicy flavors and softer scents from the traditional foods (Table 3.5, comment 3.5.5).

This finding was unanimously corroborated by all PCs. A PC indicated:

'...we still like the same foods that we used to like, but we prefer less bold flavors...'

Peer Counselor, male, Bangkok.

Theme 4: Food packaging characteristics affect nutritional supplement preference

Participants' perceptions about product packaging emerged as a driver for product acceptance or rejection. Participants consistently indicated that a packet should be 'small enough to carry in errands,' 'like a snack, something you can eat anytime,' 'something you carry around with you.' Unanimously, participants expressed a preference for small packets that can go unnoticed to avoid calling the attention of people. Food from small packets could be consumed in secrecy if necessary, preventing possible stigma related to consuming a nutritional supplement linked to having HIV.

PCs indicated that maintaining HIV status undisclosed allows PLHIV to remain part of society and keep working. A PC explained:

'...I had AIDS, I was frequently sick and I lost my job. My family disguised me and I lost most of my friends. The media of that time (referring to the 80s) frightened people about HIV ...we were and still are stigmatized...We need to be very careful with what we do to avoid calling the attention of friends and family.'

Peer Counselor, male, Bangkok.

Other important packaging characteristics that participants indicated as important to accepting a nutritional supplement are that they display 'manufacture and expiry dates,' 'pictures showing the type of product that is inside the packet,' 'ingredients, and nutritional information.' Health claims, e.g. messages indicating: it 'helps to gain weight,' and it 'gives energy' were also indicated as cues that may foster product consumption. The products that were in packages with the described characteristics were perceived as being of good quality.

Unanimously, participants indicated that a product with 'soft packaging material,' as well as the absence of 'manufacture and expiry dates,' 'ingredients' and 'nutritional information' is avoided because the product is perceived to be of 'low quality;' 'it cannot be trusted' and 'may be dangerous for health.' Big packages were unanimously disliked because they were perceived to be 'difficult to carry on errands,' and a potential risk to 'disclose HIV status.'

Theme 5: Peer Counselors may support nutritional supplement consumption

Most of the participants indicated that PCs are the best people to distribute the product and give advice on its use. The advice provided by PCs is followed because they are considered 'peers that overcame critical phases of AIDS and can teach with their own life experience how health can be improved by taking the meds, eating healthy, avoiding alcohol, and doing exercise.' Furthermore, the majority of participants indicated that PCs use an easy language when communicating messages. They also indicated that a nutritional supplement, as well as the indications for its use, should be prescribed by PCs:

'The PCs are the best at providing information and advice. Their words are clear and easy to understand. The product should be distributed in the clinic or at hospitals through the group meetings, I mean, the PLHIV groups where PCs give advice... If we see this special food in the group setting, we know it is for PLHIV and PCs can tell us how to use it."

PLHIV, female, Bangkok.

Seven out of 19 participants indicated that they would prefer a nutritionist or a doctor to distribute the product because of credibility. One participant said that anyone trained to provide counseling on the product could do it.

DISCUSSION

Several studies have focused on identifying barriers to the acceptance and adherence to RUTF in African countries. These studies have investigated programmatic issues such as duration of treatment (i.e. more than four months), education strategies (M. A. Kebede & J. Haidar, 2014), as well as health challenges such as nausea, vomiting, diarrhea, and lack of appetite (F. Dibari, P. Bahwere, et al., 2012; M. A. Kebede & J. Haidar, 2014; M. F. Olsen et al., 2013; S. Rodas-Moya et al., 2015). Some studies have also identified

sensorial attributes of RUTF that result in barriers to its acceptance i.e. taste and consistency (F. Dibari, P. Bahwere, et al., 2012; M. A. Kebede & J. Haidar, 2014). However, the psychosocial factors that play a role in the acceptability of food and nutritional supplements have not been investigated in depth. To our knowledge, the present study provides a first approach to elucidate the psychosocial factors influencing food choices and the acceptability of five potential nutritional supplements among adult PLHIV living in South Asia, specifically in Bangkok, Thailand.

We found that PLHIV choose their food based on food social values, sensory attributes, perception of self-efficacy and perceptions of the potential impact that foods can have on their health status. Moreover, all participants voiced concern about being stigmatized and discriminated if they were found to eat a 'strange food,' or food packaged in 'big containers' on a regular basis. Unfamiliar foods were widely rejected because its consumption was perceived to be a behavior that could not be integrated into their daily lives and because they were disliked. Rozin and Cantarero rationalize that people prefer to consume foods that are symbolically associated with their culture because this is consistent with their eating habits and it also contributes to reinforce people's sense of belonging to their own culture (L. Cantarero et al., 2012; Rozin & Vollmecke, 1986b).

Likewise, consumption of foods perceived to place people into a lower socioeconomic status was rejected. This finding points out the importance of social structures in shaping eating habits and suggests that when developing nutritional supplements, a food or drink that fits into the particular socioeconomic context should be chosen. In accordance to the Social Cognitive Theory (SCT), a behavior that may not be accepted in a social context may result in an impediment to the adoption of such behavior (Bandura, 2004). For the development of nutritional supplements for PLHIV, it needs to be considered that food choices are related to social values. These values represent a desired end state of psychological wellbeing linked to the adoption of socially accepted behaviors.

The sensory attributes of food also emerged as key factors influencing the acceptability of food and nutritional supplements among PLHIV. Foods that are traditionally consumed in a setting have sensory attributes that are unique to these foods (P. Rozin, 1990; Rozin & Vollmecke, 1986b). Monge-Rojas and colleagues (Monge-Rojas et al., 2014), in consistency with other authors (Connors, Bisogni, Sobal, & Devine, 2001; Rozin & Vollmecke, 1986a), pointed out that sensory attributes of food are universally high-ranking factors that influence food choices across populations worldwide

(Monge-Rojas et al., 2014). Palatable sensory attributes of food (e.g. flavor, smell, texture and appearance) are associated with higher amounts of consumption of these foods and with a higher frequency of consumption in the long term (de Graaf et al., 2005).

Our findings suggest that the main sensory characteristics that can influence the acceptance of food among PLHIV in Thailand are textures, flavors and scents. A preference for soft textures from food and slightly thick beverages, as well as less bold flavors and scents, and slightly sweet and sour flavors for drinks were indicated by the majority of participants. Interestingly, we found similar preferences for sensory attributes of food and drinks in our formative research conducted among PLHIV in Malawi (S. Rodas-Moya et al., 2015). Our findings suggest that preferences for sensory attributes are also influenced by HIV and the associated health challenges. When exploring preferences for nutritional supplements, in both, Thailand and Malawi, A preference for nutritional supplements in liquid form was found (S. Rodas-Moya et al., 2015). In Thailand, PLHIV unanimously indicated a preference for the yogurt drink, and some participants also indicated a preference for a nutritional supplement in the form of soy milk.

Nevertheless, although in consistence with other studies, (Connors et al., 2001; Monge-Rojas et al., 2014; Rozin & Vollmecke, 1986b), our results indicate that sensory properties of food are among the most important drivers of food choice and acceptance, in concurrence with Boelsma and colleagues, this study suggests that guarantying the presence of pleasant sensory attributes in food products does not ensure that the product will be accepted for habitual consumption in the long term (Boelsma, Brink, Stafleu, & Hendriks, 2010). In line with Patel and Boelsma (Boelsma et al., 2010; Patel & Schlundt, 2001), we found that among PLHIV, appreciation for food is also affected by perceptions on psychological and physical wellbeing. In agreement with these perceptions, Boelsma has pointed out that consumers' general feeling of wellness after food consumption (postprandial wellness) may play an important role in food intake and may be an important factor predicting consumption of products in the long term (Boelsma et al., 2010).

Our results suggest that the perceptions of PLHIV that influence their psychological and physical well-being may be the result of a combination of factors, such as those related to self-efficacy toward eating certain types of foods as well as the expected health outcomes from food intake (e.g. post-prandial wellness, the sensation of gaining energy and weight gain) (Bandura, 2004). Self-efficacy is the extent to which someone feels he or she can exert control over her/his own habits (Bandura, 2004). Our data suggest that the self-

efficacy of PLHIV toward eating certain foods was important because it refers to their confidence to control their daily diets. In this regard, our study sample explained higher confidence to consume foods and drinks that are palatable, easy to chew and swallow, and culturally appropriate–key themes underlying self-efficacy. Other important themes that emerged in relation to the self-efficacy of PLHIV included having economic and physical access to high-quality foods, as well as being able to access foods that are "easy to prepare" and "carry [home]." Together, these psycho-social factors contributed to the confidence level of PLHIV to control their dietary behaviors in the face of illness. Therefore, a food, drink, or nutritional supplement that fits the aforementioned criteria may be most appropriate for the diets of PLHIV.

Lastly, we found that the information provided through nutritional counseling services at the Anonymous Clinic of the TRCARC, and conveyed by PCs, seems to influence food preferences in this population group. This result is consistent with findings from a systematic review among Latino populations in the United States of America in which the role of peers or community health workers has been highlighted as effective in promoting the adoption of health-related behaviors (Pérez-Escamilla, Hromi-Fiedler, Vega-López, Bermúdez-Millán, & Segura-Pérez, 2008). In this systematic review peers were defined as community workers with the same socioeconomic status as those they serve, and with similar cultural and social life experiences as their target clients (Pérez-Escamilla et al., 2008). In our study, PCs fit this description and they were described as 'peers that can teach with their life example.' This may explain the influence they have in promoting healthy eating habits and healthy life styles in general.

From the viewpoint of the SCT (Bandura, 2004), our results suggest that information about risks and benefits of consuming specific foods, and the perceived self-efficacy to control which foods to include in their own food systems, could be key factors that influence food choices among PLHIV. However; the perceived risk of stigma linked to the consumption of unfamiliar foods, emerged as the main socio-structural determinant influencing food choices among PLHIV. People internalize the public attitudes and suffer negative consequences on their self-efficacy and outcome expectations. Therefore, PLHIV may prefer to adopt dietary habits that converge with those of their social environment; because transgressing cultural accepted norms has a high social cost.

This study presents a first approach to the psychosocial factors that influence the choice of food and nutritional supplement among PLHIV. However, this study has some limitations. The sample of participants belongs to a group of

PLHIV attending the clinic of the TRCARC. This clinic is well-known for providing high-quality service of health care and nutritional counseling to PLHIV who live in or frequently visit Bangkok. Therefore, the findings from this study may not be transferable to all PLHIV attending clinics throughout Thailand. Furthermore, Thailand is an upper-middle income country; hence, despite the fact that we included mainly participants from the first and second lowest economic quintiles, they were not a food insecure population. Food preferences and eating practices of PLHIV living in low income Asian countries and without access to high quality health care facilities may differ. Thus, our results may only be transferable to major segments of populations of similar socioeconomic scenarios (Morse, 1999).

The present study highlights the role of psychosocial factors in influencing food preferences among PLHIV. We found that food social values, sensorial properties of food, psychological perceptions of wellbeing and physical wellbeing as a result of food intake, as well as social environments play a key role in shaping preferences for food and nutritional supplements among PLHIV. In this setting a nutritional supplement in the form of a typical drink, preferably of liquid-thick consistency and packed in small portable containers, could be well accepted. Given the importance of sensory attributes of food and drinks, a combination of sensory studies should be used to develop the nutritional supplement. Considering the influence of psychosocial factors in the acceptance of a food product, formative research should also be employed to understand potential barriers to and enablers of the acceptability of the new nutritional supplement in the long term and in habitual living conditions.

ACKNOWLEDGEMENTS

We would like to thank The Thai Red Cross AIDS Research Center (TRCARC) team for supporting us with the conduct of the present study. Special thanks to our team of data collectors, the master students from Science Program in Nutrition and Dietetics, Institute of Nutrition, Mahidol University, Thialand: Alongkote Singhato, Wacharin Suksanan, Natthaphon Thatsanasuwan and Haneefah Wangsoh for their dedicated work. We are particularly grateful to all people living with HIV and the peer counselors who participated in this study and to the nutrition department of the TRCARC. This work was funded by the United Nations World Food Programme as part of its partnership with DSM, Heerlen, Netherlands. Authors affiliated to WFP decided on study design, conduct and preparation of the manuscript. Hence, there is no conflict of interest to declare.

References

Ahoua, L., Umutoni, C., Huerga, H., Minetti, A., Szumilin, E., Balkan, S., . . . Pujades-Rodriguez, M. (2011). Nutrition outcomes of HIV-infected malnourished adults treated with ready-to-use therapeutic food in sub-Saharan Africa: a longitudinal study. *J Int AIDS Soc, 14*, 2. doi:10.1186/1758-2652-14-2

Argemi, X., Dara, S., You, S., Mattei, J. F., Courpotin, C., Simon, B., . . . Lefebvre, N. (2012). Impact of malnutrition and social determinants on survival of HIV-infected adults starting antiretroviral therapy in resource-limited settings. *AIDS, 26*(9), 1161-1166. doi:10.1097/QAD.0b013e328353f363

Bahwere, P., Sadler, K., & Collins, S. (2009). Acceptability and effectiveness of chickpea sesame-based ready-to-use therapeutic food in malnourished HIV-positive adults. *Patient Prefer Adherence, 3*, 67-75.

Bandura, A. (2002). Social cognitive theory in cultural context. *Applied Psychology, 51*(2), 269-290.

Bandura, A. (2004). Health promotion by social cognitive means. *Health education & behavior, 31*(2), 143-164.

Berhe, N., Tegabu, D., & Alemayehu, M. (2013). Effect of nutritional factors on adherence to antiretroviral therapy among HIV-infected adults: a case control study in Northern Ethiopia. *BMC Infect Dis, 13*, 233. doi:10.1186/1471-2334-13-233

Boelsma, E., Brink, E. J., Stafleu, A., & Hendriks, H. F. (2010). Measures of postprandial wellness after single intake of two protein–carbohydrate meals. *Appetite, 54*(3), 456-464.

Brown, A. (2008). Understanding Food: principles & preparation. 3 d ed. Thomson Learning: Inc.

Byron, E., Gillespie, S., & Nangami, M. (2008). Integrating nutrition security with treatment of people living with HIV: lessons from Kenya. *Food Nutr Bull, 29*(2), 87-97.

Cantarero, L., Espeitx, E., Gil Lacruz, M., & Martin, P. (2012). Human food preferences and cultural identity: The case of Aragon (Spain). *Int J Psychol*. doi:10.1080/00207594.2012.692792

Charmaz, K. (2006). *Constructing grounded theory*. London ; Thousand Oaks, Calif.: Sage Publications.

Charmaz, K. (2014). *Constructing grounded theory*: Sage.

Connors, M., Bisogni, C. A., Sobal, J., & Devine, C. M. (2001). Managing values in personal food systems. *Appetite, 36*(3), 189-200. doi:10.1006/appe.2001.0400

Creswell, J. W., & Creswell, J. W. (2013). *Qualitative inquiry and research design : choosing among five approaches* (3rd ed.). Los Angeles: SAGE Publications.

de Graaf, C., Kramer, F. M., Meiselman, H. L., Lesher, L. L., Baker-Fulco, C., Hirsch, E. S., & Warber, J. (2005). Food acceptability in field studies with US army men and women: relationship with food intake and food choice after repeated exposures. *Appetite, 44*(1), 23-31.

de Pee, S., & Semba, R. D. (2010). Role of nutrition in HIV infection: review of evidence for more effective programming in resource-limited settings. *Food Nutr Bull, 31*(4), S313-344.

Dibari, F., Bahwere, P., Le Gall, I., Guerrero, S., Mwaniki, D., & Seal, A. (2012). A qualitative investigation of adherence to nutritional therapy in malnourished adult AIDS patients in Kenya. *Public Health Nutr, 15*(2), 316-323. doi:10.1017/S1368980010003435

Diouf, A., Badiane, A., Manga, N. M., Idohou-Dossou, N., Sow, P. S., & Wade, S. (2016). Daily consumption of ready-to-use peanut-based therapeutic food increased fat free mass, improved anemic status but has no impact on the zinc status of people living with HIV/AIDS: a randomized controlled trial. *BMC public health, 16*(1), 1.

Duggal, S., Chugh, T. D., & Duggal, A. K. (2012). HIV and malnutrition: effects on immune system. *Clin Dev Immunol, 2012*, 784740. doi:10.1155/2012/784740

Evans, D., McNamara, L., Maskew, M., Selibas, K., van Amsterdam, D., Baines, N., . . . Sanne, I. (2013). Impact of nutritional supplementation on immune response, body mass index and bioelectrical impedance in HIV-positive patients starting antiretroviral therapy. *Nutr J, 12*(1), 111. doi:10.1186/1475-2891-12-111

Forrester, J. E., & Sztam, K. A. (2011). Micronutrients in HIV/AIDS: is there evidence to change the WHO 2003 recommendations? *The American journal of clinical nutrition, 94*(6), 1683S-1689S.

Grinspoon, S., Mulligan, K., Department of, H., Human Services Working Group on the, P., Treatment of, W., & Weight, L. (2003). Weight loss and wasting in patients infected with human immunodeficiency virus. *Clin Infect Dis, 36*(Suppl 2), S69-78. doi:10.1086/367561

Ivers, L. C., Cullen, K. A., Freedberg, K. A., Block, S., Coates, J., & Webb, P. (2009). HIV/AIDS, undernutrition, and food insecurity. *Clin Infect Dis, 49*(7), 1096-1102. doi:10.1086/605573

Kebede, M. A., & Haidar, J. (2014). Factors influencing adherence to the food by prescription program among adult HIV positive patients in Addis Ababa, Ethiopia: a facility-based, cross-sectional study. *Infect Dis Poverty, 3*, 20. doi:10.1186/2049-9957-3-20

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative data analysis : a methods sourcebook* (Third edition. ed.). Thousand Oaks, Californinia: SAGE Publications, Inc.

Monge-Rojas, R., Mattei, J., Fuster, T., Willett, W., & Campos, H. (2014). Influence of sensory and cultural perceptions of white rice, brown rice and beans by Costa Rican adults in their dietary choices. *Appetite, 81*(0), 200-208. doi:http://dx.doi.org/10.1016/j.appet.2014.06.028

Morse, J. M. (1999). Qualitative generalizability. *Qualitative health research, 9*(1), 5-6.

Ndekha, M. J., van Oosterhout, J. J., Zijlstra, E. E., Manary, M., Saloojee, H., & Manary, M. J. (2009). Supplementary feeding with either ready-to-use fortified spread or corn-soy blend in wasted adults starting antiretroviral therapy in Malawi: randomised, investigator blinded, controlled trial. *BMJ, 338*, b1867. doi:10.1136/bmj.b1867

Olsen, M. F., Tesfaye, M., Kaestel, P., Friis, H., & Holm, L. (2013). Use, perceptions, and acceptability of a ready-to-use supplementary food among adult HIV patients initiating antiretroviral treatment: a qualitative study in Ethiopia. *Patient Prefer Adherence, 7*, 481-488. doi:10.2147/PPA.S44413

Patel, K. A., & Schlundt, D. (2001). Impact of moods and social context on eating behavior. *Appetite, 36*(2), 111-118.

Patton, M. Q. (2002a). *Qualitative research & evaluation methods : integrating theory and practice* (Fourth edition. ed.). Thousand Oaks, California: SAGE Publications, Inc.

Patton, M. Q. (2002b). *Qualitative research and evaluation methods* (3 ed.). Thousand Oaks, Calif.: Sage Publications.

Pérez-Escamilla, R., Hromi-Fiedler, A., Vega-López, S., Bermúdez-Millán, A., & Segura-Pérez, S. (2008). Impact of peer nutrition education on dietary behaviors and health outcomes among Latinos: a systematic literature review. *Journal of nutrition education and behavior, 40*(4), 208-225.

Preedy, V. R. (2012). *Handbook of anthropometry : physical measures of human form in health and disease*. New York: Springer.

Rodas-Moya, S., Kodish, S., Manary, M., Grede, N., & de Pee, S. (2015). Preferences for food and nutritional supplements among adult people living with HIV in Malawi. *Public Health Nutr*, 1-10. doi:10.1017/S1368980015001822

Rodas-Moya, S., Kodish, S., Manary, M., Grede, N., & de Pee, S. (2016). Preferences for food and nutritional supplements among adult people living with HIV in Malawi. *Public Health Nutr, 19*(4), 693-702. doi:10.1017/S1368980015001822

Rozin, P. (1990). Acquisition of stable food preferences. *Nutrition reviews, 48*(2), 106-113; discussion 114-131.

Rozin, P., & Vollmecke, T. A. (1986a). Food likes and dislikes. *Annu Rev Nutr, 6*, 433-456. doi:10.1146/annurev.nu.06.070186.002245

Rozin, P., & Vollmecke, T. A. (1986b). Food likes and dislikes. *Annual review of nutrition, 6*, 433-456.

Sandelowski, M. (2000). Combining qualitative and quantitative sampling, data collection, and analysis techniques in mixed-method studies. *Res Nurs Health, 23*(3), 246-255.

Tang, A. M. (2003). Weight loss, wasting, and survival in HIV-positive patients: current strategies. *AIDS Read, 13*(12 Suppl), S23-27.

UNAIDS. (2015). *Thailand AIDS Response Progress Report* Retrieved from Thailand:

World Food Programme (WFP)., UNAIDS)., & U.S. President's Emergency Plan for AIDS Relief (PEPFAR). (2014). Nutrition assessment, counselling and support for adolescents and adults living with HIV : a programming guide : FOOD AND NUTRITION IN THE CONTEXT OF HIV AND TB. Geneva UNAIDS

UNAIDS. (2015). *Thailand AIDS Response Progress Report* Retrieved from Thailand:

World Food Programme (WFP)., UNAIDS)., & U.S. President's Emergency Plan for AIDS Relief (PEPFAR). (2014). Nutrition assessment, counselling and support for adolescents and adults living with HIV : a programming guide : FOOD AND NUTRITION IN THE CONTEXT OF HIV AND TB. Geneva UNAIDS.

Chapter 4

Olfactory and gustatory function of adults and adult people living with HIV (PLHIV) in Malawi

Santiago Rodas-Moya
Cees de Graaf
Saskia de Pee
Sanne Boesveldt

Manuscript in preparation for submission

ABSTRACT

HIV has been associated with olfactory and gustatory (chemosensory) losses. Chemosensory loss may affect preferences for food leading to reduced food intake, weight loss, and malnutrition. Several studies have reported olfactory and gustatory losses among people living with HIV (PLHIV). However, the evidence is mixed. Different methods and tools to assess the olfactory function of PLHIV with different clinical stages and small sample sizes may explain the inconsistent results. We conducted a cross-sectional study to investigate the olfactory and gustatory function of 100 male and female PLHIV on antiretroviral therapy from clinical stages 1 and 2. Participants were from Chilomoni, a rural community in Blantyre, Malawi. One-hundred healthy individuals of comparable socio-economic characteristics also participated. We used the Snifin' Sticks and Taste Strips to assess their olfactory and gustatory function, respectively. Olfactory thresholds (T), olfactory discrimination (D) and identification (I) abilities were evaluated. The combined TDI score was used to estimate participants' olfactory function. The gustatory function assessment consisted of evaluating participants' ability to identify the tastes: sweet, sour, salty, and bitter. The gustatory function was estimated using the combined total taste score (TTS) of the four tastes. The t-test for independent samples showed statistically significant ($p < 0.05$) differences between the olfactory function of PLHIV and healthy adults. No significant difference ($P > 0.05$) were found in the gustatory function of both groups. Our results suggest that PLHIV tend to develop hyposmia (average TDI < 30.3), but not hypogeusia (average TTS > 9).

INTRODUCTION

Taste and smell (chemosensory) function play an important role in food selection and dietary intake. The aroma and taste of food elicit pleasant or unpleasant sensations that are partly responsible for food choices (Boesveldt & de Graaf, 2017). Taste and smell losses may impair food perception leading, in some cases, to changes in eating habits, reduction of dietary intake, and weight loss (Rolls, 1999; Seo & Hummel, 2009). The chemosensory function is fundamental for food enjoyment, safety, and quality of life, and it may also play an important role in the maintenance of optimal nutritional status.

There are several causes for losing the olfactory and gustatory function. One of them is HIV infection. HIV has been associated with cognitive and neurosensory dysfunction, including olfactory (Braimah & Onyeagwara, 2019; Zucco & Ingegneri, 2004) and gustatory losses (Henn et al., 2017). Chemosensory loss may also contribute to malnutrition and may affect compliance with antiretroviral therapy (ART) among people living with HIV (PLHIV) (Braimah & Onyeagwara, 2019). The degree of olfactory and gustatory impairment seems to be associated with the severity of HIV infection, which increases when the immune function declines. (Zucco & Ingegneri, 2004). Different methods and tools may be used to estimate the olfactory and gustatory function of individuals. Below, we refer to studies that measured either odor thresholds, olfactory discrimination or identification abilities, taste identification or a combination of two or more of these parameters.

We found that the evidence on the olfactory and gustatory function of PLHIV is mixed. Zucco and Ingegneri (Zucco & Ingegneri, 2004) observed a progressive drop in the capacity of discriminating and identifying odors among PLHIV with high immunodeficiency stage (i.e., clinical stages > 2 defined by CD4 counts < 499 cells/μL). However, Brody and colleagues (Brody et al., 1991) found that regardless of the immunodeficiency stage, PLHIV had lower ability to identify odors than healthy age- and sex-matched individuals. Similarly, Mates and colleagues found that PLHIV are impaired to identify odors when compared to healthy individuals. However, they did not find associations between olfactory loss and immunodeficiency stages (Mattes et al., 1995). On the contrary, Mueller and colleagues (Mueller et al., 2002) found normal olfactory discrimination and identification function in PLHIV with immunodeficiency stages 1-3 (defined by the Centers for Disease Control and Prevention CDC from the USA). However, they found that PLHIV's olfactory thresholds were below the median compared to those from healthy participants. More recently, in a similar study conducted with female PLHIV in Nigeria, Fasunla

and colleagues (Fasunla et al., 2016) found olfactory thresholds, olfactory discrimination and olfactory identification abilities within normal ranges. However, PLHIV's mean olfactory scores were significantly lower when compared to those of healthy participants. In another study, Fasunla and co-workers (Fasunla, Nwankwo, Adebayo, & Nwaorgu, 2018) also assessed the olfactory and gustatory function of PLHIV from immunodeficiency stages 1, (i.e., CD4 counts ≥500 cells/μL), 2 (i.e., CD4 count 200-499 cells/μL), and 3 (CD4 counts <200 cells/μL). The authors measured olfactory thresholds, odor discrimination, and odor identification abilities, as well as the taste identification capacity of their participants. The authors concluded that PLHIV had olfactory and gustatory losses and that the severity of chemosensory loss was related to HIV-stage. Raja and colleagues assessed the gustatory function of PLHIV with and without ART (Fasunla et al., 2016). These authors found significant taste losses among PLHIV and observed that taste alteration was worst in PLHIV on ART. On the contrary, Mattes and colleagues (Mattes et al., 1995) did not find taste alterations between PLHIV compared to healthy individuals.

The disagreement on the evidence may be the result of the different methods, tools, and cut-off points used to define a normal olfactory and gustatory function. Moreover, the majority of the studies have been conducted with a relatively small number of participants, e.g., ≤ 50 participants (Brody et al., 1991; Mattes et al., 1995; Raja, Rai, Khan, Banu, & Bhuthaiah, 2013; Zucco & Ingegneri, 2004) from different HIV stages. This has resulted in an even lower number of participants from each HIV stage leading to low statistical power.

In the present study, we examined the chemosensory function of 100 PLHIV aged 18-49 years from clinical stages 1 and 2, i.e., PLHIV without major health complaints who have been recently tested HIV positive or who have HIV infection under control with ART. We also included 100 healthy adults with similar sociodemographic characteristics as a control group. We used the Snifin' Sticks and Taste Strips, to measure olfactory thresholds, odor discrimination, and identification abilities as well as the capacity of identifying tastes.

METHODS

This was a cross-sectional study conducted to estimate the olfactory and gustatory function of PLHIV and healthy adults.

Study population

One-hundred male and female PLHIV aged 18-49 years, without major health complaints and on ART participated in the study. Their stage of HIV infection was classified as clinical stages 1 and 2, according to the World Health Organization (WHO, 2005). PLHIV from clinical-stage 1 tested HIV positive recently and were on ART. PLHIV from clinical-stage 2 were receiving ART, and the HIV infection was under control. According to HIV clinical staging classification system from WHO, PLHIV from clinical-stage 1 may be asymptomatic or have persistent generalized lymphadenopathy. PLHIV from clinical-stage 2 may have experienced recent unexplained weight loss of less than 10 percent of total body weight, recurrent respiratory infections, e.g., sinusitis, bronchitis, otitis media, and pharyngitis and/or dermatological pathologies such as mouth sores, herpes zoster, angular cheilitis, papular pruritic eruptions, seborrhoeic dermatitis, and fungal nail infections (WHO, 2005). The WHO HIV clinical stages are routinely used by the health care personnel of Chilomoni clinic, and other health care facilities in Malawi to assess their clients. We also included 100 healthy male and female adults of comparable age, gender, income level, and from the same ethnicity.

Exclusion criteria for all participants included heavy smoking and heavy drinking habits; or occupational exposure to volatile organic compounds such as solvents, varnishes, lacquers, dyes (among others). Any of these conditions may cause olfactory and gustatory disturbances (Gobba, 2003). We also excluded subjects with a history of head trauma because that may also cause loss of olfaction (Howell, Costanzo, & Reiter, 2018).

PLHIV and healthy subjects were recruited by the Health Surveillance Assistants (HSAs) of Chilomoni clinic who received the list of inclusion and exclusion criteria. The HSAs are health-care workers who perform health promotion activities in rural communities and at Chilomoni clinic in Blantyre. The HSAs contacted PLHIV at Chilomoni Clinic and the adults without health challenges in their houses. The study was undertaken during July and August 2016.

Procedures for data collection

This study was conducted following the *Guidelines for Biomedical Studies Involving Human Subjects (Helsinki Declaration)* and was approved by the College of Medicine Research Ethics Committee (COMREC) from the University of Malawi (P.08/15/1780).

We trained a team of five bilingual (English and Chichewa) research assistants during two weeks to conduct the chemosensory assessments using the "Sniffin' Sticks" and "Taste Strips" from Burghart, Wedel, Germany. The instruments for data collection were developed in English and translated to Chichewa by two data collectors. To check the accuracy of translations, two different data collectors back-translated the instruments from Chichewa into English. Minor adjustments were made. The tests were conducted in local langue (Chichewa) in a well-ventilated and illuminated room, free of extraneous odors and noise at Chilomoni clinic. Five individual sensory booths were arranged with tables and chairs. The booths were placed with a distance of ~1.5 m2 between participants. PLHIV and healthy adults did not smoke, eat, or drink anything other than water and did not brush their teeth at least 1 hour before taking the olfactory and gustatory tests (B. N. Landis et al., 2009).

Assessment of olfactory function with the Sniffin' Sticks

The Sniffin' Sticks are pen-like devices of ~14 cm length and a diameter of 1.3 cm. The Sniffin' Sticks have tampons filled with 4 ml of liquid odorants or solvents. To expose participants to the Sniffin' Sticks, the cap was removed by the examiner for approximately 3 seconds, and the pen's tip was placed approximately 2 cm away from the participants' nostrils, in the center. We used three test kits to asses the olfactory function: odor threshold (OT), odor discrimination (OD), and odor identification (OI). Results from the three tests were summed up to present the threshold-discrimination-identification (TDI) score, which provides estimates of olfactory function (T Hummel, Kobal, Gudziol, & Mackay-Sim, 2007).

Odor thresholds (OT)

The OT test measures the lowest concentration of n-butanol that an individual can perceive. Thresholds are determined by the administration of 16 increasing concentrations of n-butanol. The 16 dilutions of n-butanol were presented in geometric series starting from a 4% n-butanol solution (dilution ratio 1:2 in deionized aqua conservata as solvent). The pens were arranged in triplets with one pen containing the n-butanol and two pens the solvent. Triplets were presented at intervals of ~20 seconds. OT was assessed using

a staircase, triple-forced-choice procedure. The three pens were presented in a randomized order. The participants were requested to identify the pen containing the n-butanol. Reversal of the staircase was done when the odor was correctly identified for two consecutive times. The olfactory threshold of a participant was defined as the mean of the last four of seven staircase reversals. The participants could obtain a score from 1 to 16. Lower scores reflect higher olfactory thresholds, thus, lower olfactory acuity. To avoid that participants could identify the order of presentation of the Sniffin' Sticks, they were blindfolded with sleeping masks.

Odor discrimination

Sixteen triplets of odor-containing pens were presented following a three-alternative forced-choice procedure. Each triplet had two pens containing the same odor, and one pen a different odor. The task of the participant was to identify the pen that smelled different. Triplets were presented in intervals of ~20 seconds. Each correct answer scored 1 point. The scores ranged from 0 to 16. Participants were also blindfolded.

Odor identification

Although the validity of the identification test has been tested in different countries, and normative data have been published (T Hummel et al., 2007), the "16 Blue" identification test kit contains odorants that may not be familiar for Malawians (e.g., licorice, rose, leather, and others). To increase the likelihood that the participants could correctly identify the odors, we combined odorants from the validated standard identification test kit "16 Blue" (T Hummel et al., 2007) and the "extended" identification test kit "16 Purple", both from Burghart, Wedel, Germany.

Using the 32 odorants, we conducted a familiarity test following recommendations by Hummel and colleagues (Thomas Hummel, Sekinger, Wolf, Pauli, & Kobal, 1997). For each odor; four descriptors were presented in the form of words on a card. The order of the descriptors was pre-arranged by the manufacturer. Once the participant had chosen the odorant, he/she was requested to indicate how familiar the odor was on a 6-point scale with the anchors "unknown" on the left side and "highly familiar" on the right side. The familiarity test was conducted with 55 male (n = 23) and female (n = 32) healthy Malawian adults aged 18-49 years recruited by the HSAs in their households.

We selected 16 odorants with the highest percentage of correct recognition and familiarity scores (Table 4.1).

Table 4.1. List of odorants selected for the olfactory identification test with familiarity scores and percentages of correct recognition.

IDE-Malawi	Mean familiarity score	Correctly identified (%)
Peppermint	5.7	98
Banana	5.8	89
Fish	5.7	83
Garlic	5.7	81
Caramel	5.5	78
Turpentine	5.1	77
Grass	5.1	76
Orange	5.4	75
Coke	5.4	75
Lemon	5.2	74
Mushroom	5.3	73
Pineapple	5.2	72
Coffee	5.2	71
Apple	5.1	70
Melon	5.0	64
Rose	4.8	62

However, although Hummel and colleagues recommend excluding odorants with a correct proportion of recognition < 75% (Thomas Hummel et al., 1997), due to a lack of additional odor items, we included seven odorants with a correct proportion of recognition < 75%. The familiarity scores of the selected odorants ranged from 4.8 to 5.8.

Odor identification testing involved the identification of the 16 selected odorants showed in Table 4.1. For each odor pen, the participant had four descriptors presented in the form of words on a card. On a multiple-choice task, participants were requested to indicate which odor descriptor best described the odor from the pen. Each odor pen was presented with intervals of ~20 seconds. The participants could score from 0 to 16 points, one point for each correctly identified odor.

The results from OT, OD, OI were combined to form the TDI score (maximum score of 48). Disregarding gender differences, the TDI score at the 10th percentile from

the normative data (T Hummel et al., 2007) was used to define hyposmia, i.e., ≤ 30.3 for participants 18-35 years, and ≤ 27.3 for participants 36-50 years.

Gustatory tests

To assess the gustatory function of participants, we used the Taste Strips (Basile Nicolas Landis et al., 2009) from Burghart, Wedel, Germany. The taste strips are spoon-shaped filter papers with a length of 8 cm and a tip area of 2 cm^2. The gustatory test measures the lowest concentration of a taste that a person can correctly identify (Basile Nicolas Landis et al., 2009). The taste strips contain four basic tastes: sweet, sour, salty, and bitter at four different concentrations (sweet: 0.4, 0.2, 0.1, 0.05 g/ml sucrose; sour: 0.3, 0.165, 0.09, 0.05 g/ml citric acid; salty: 0.25, 0.1, 0.04, 0.016 g/ml sodium chloride; bitter: 0.006, 0.0024, 0.0009, 0.0004 g/ml quinine hydrochloride). A blank (no taste) is also included.

During the test, we asked the participants to open their moth and extend their tongue. A taste strip was placed at the middle of the anterior third of the tongue (non-lateralized test). The Participants were requested to close their mouth, move the tongue smoothly, and to indicate the taste perceived (i.e., salty, sour, sweet, bitter, or nothing). To familiarize participants with the procedure and to test whether they were able to identify the different tastes correctly, taste strips with the highest concentration of each taste (taste high) were presented in random order.

Sixteen taste strips, four of each taste, and three blank strips were presented. The test was a multiple forced-choice. Each taste quality was presented at increasing concentrations following a pseudo-randomized scheme (Basile Nicolas Landis et al., 2009). The taste strips were presented with intervals of ~30 seconds. Before and between each administration of a taste strip, participants were requested to rinse their mouth with plain water. Each correctly identified taste received a score of one. The maximum score for each taste was 4 and 16 for the total taste score (TTS). Disregarding gender and age, the TTS score < 9 was used to define hypogeusia as recommended in the users' manual of the Taste Strips from Burghart, Wedel, Germany.

Statistical analysis

We used Chi-square tests of homogeneity for comparing multinomial sociodemographic and health variables of PLHIV and the adults without health complaints. We used independent-samples t-test to investigate significant differences in the olfactory and gustatory function of PLHIV and healthy adults. Welch's correction was used when unequal variances were

found (Welch, 1947). Descriptive data are presented as means and standard deviations. The alpha level was set at 0.05. Data were analyzed with SPSS 23.

RESULTS

Two-hundred male (n =102) and female (n = 98) PLHIV and healthy adults took part in the study. Participants from both groups belonged to the same ethnicity. Gender, age range, and income, as well as BMI category, smoking habits, and alcohol consumption patterns, were comparable between the two groups. However, their education level differed. The sociodemographic and health characteristics of the participants are presented in Table 4.2.

Table 4.2. Demographic and health characteristics of PLHIV and controls

	PLHIV (n = 100)	**Controls** (n = 100)	X^2	***P* value**
Mean age and (SD[1])	34.8 ± 7.2	31.6 ± 10.3		
Age groups (y.)				
18-35	51	47	0.32	0.67
36-50	49	53		
Gender				
Male (n)	51	51	0.00	1.00
Female (n)	49	49		
Education				
Less than high school	57	20	34.97	<0.05
High school	42	65		
Above high school	1	15		
Income in MWK[2]				
0–6000	12	27	8.46	0.21
6001–12000	24	19		
>12000	64	54		
BMI [kg/m2]				
< 18.5	28	16	4.24	0.12
18.5-24.99	60	71		
25-29.99	12	13		
Smoking status				
Yes	9	2	4.71	0.06
No	91	98		
Alcohol consumption				
None	85	90	8.04	0.09
Rarely	4	1		
Once a month	3	7		
Once a week	7	1		
Most days of the week	1	1		

WHO HIV-staging				
Stage 1	19	NA[6]	NA	NA
Stage 2	81			
ART regime				
5A[3]	95	NA	NA	NA
2A[4]	3			
2P[5]	2			

[1] Standard Deviation
[2] Malawian Kwacha (Exchange rate when conducting the study: U$D 1 = 710 MWK)
[3] 5A Tenofovir disoproxil fumarate 300 mg; lamivudine 300 mg; efaviren 600 mg
[4] 2A Zidovudine 300 mg; lamivudine 150 mg; nevirapine 200 mg
[5] 2P Zidovudine 60 mg; lamivudine 30 mg; nevirapine 50 mg
[6] Not applicable

Olfactory function

Table 4.3 shows the means and standard deviations of OT, OD, OI, and TDI scores.

Table 4.3. Mean scores of olfactory functions from PLHIV and controls measured with olfactory thresholds (OT), olfactory discrimination (OD), olfactory identification (OI), and the composed threshold, discrimination and identification (TDI) score. Data are presented by gender and age group.

Gender	**Male**			**Female**		
HIV status	PLHIV	Controls	P value	PLHIV	Controls	P value
	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
Age range						
18-35 y	n = 27	n = 24		n = 24	n = 23	
OT	5.6 ± 1.5	6.9 ± 2.5	**0.036**	6.3 ± 1.2	8.5 ± 2.2	**0.000**
OD	11.7 ± 1.8	12.3 ± 2.3	0.249	10.8 ± 2.1	11.9 ± 2.0	0.068
OI	10.3 ± 2.4	11.5 ± 1.7	**0.048**	10.7 ± 1.7	12.4 ± 1.6	**0.001**
TDI	27.6 ± 3.9	30.7 ± 4.2	**0.009**	24.5 ± 5.1	33.0 ± 3.9	**0.000**
Age range						
36-50 y	n = 24	n = 27		n = 25	n = 26	
OT	5.3 ± 1.8	5.9 ± 2.7	0.368	5.7 ± 1.1	7.2 ± 1.1	**0.000**
OD	10.0 ± 2.8	11.5 ± 1.6	**0.027**	10.0 ± 1.7	11.5 ± 1.5	**0.003**
OI	9.4 ± 2.4	11.3 ± 1.9	**0.003**	10.3 ± 1.9	11.5 ± 1.8	**0.024**
TDI	24.5 ± 5.1	28.0 ± 4.5	**0.011**	27.6 ± 4.7	28.9. ± 3.9	0.284

We found statistically significant differences in the olfactory function of PLHIV and healthy participants. For the age group 18-35 y., the mean TDI score of male PLHIV was 27.6 ± 3.9 compared to 30.7 ± 4.2 from healthy males (t = 2.71, P = 0.009). Among females, the mean TDI score from HIV-positive participants was 24.5 ± 5.1 compared to 33.0 ± 3.9, from healthy women (t = 6.48, p = 0.000). Using the TDI score from the normative data (T Hummel et al., 2007) at the

10th percentile as reference (TDI ≤ 30.3 for participants 18-35 years), our data suggest that male and female PLHIV in this age group tend to develop hyposmia. Among participants 36-50 years, the mean TDI score of HIV-positive males was 24.5 ± 5.1, compared to 28.0 ± 4.5 from healthy males (t = 2.63, P = 0.011). However, among women, the mean TDI score from HIV-positive participants was 27.6 ± 4.7 compared to 28.9 ± 3.9 from healthy females (t = 1.08, P = 0.284). Considering the TDI score from the normative data (T Hummel et al., 2007) at the 10th percentile for this age group (TDI ≤ 27.3 for people 36-50 y.), our data suggest that male PLHIV tend to develop hyposmia. However, HIV positive and HIV negative women seem to have a normal olfactory function.

Gustatory function

Means and standard deviations of the four taste qualities and the TTS score are presented in Table 4.4.

Table 4.4. Mean scores of gustatory function for PLHIV and controls measured with the taste qualities sweet, sour, salty, bitter and the composed total taste score (TTS). Data are presented by gender and age group.

Gender	**Male**			**Female**		
HIV status	**PLHIV**	**Controls**	**P value**	**PLHIV**	**Controls**	**P value**
	Mean ± SD	**Mean ± SD**		**Mean ± SD**	**Mean ± SD**	
Age range						
18-40 y	n = 22	n = 24		n = 29	n = 37	
Sweet	3.2 (± 0.8)	3.7 (± 0.6)	0.07	3.4 (± 0.9)	3.5 (± 0.8)	0.60
Sour	2.6 (± 1.1)	2.2 (± 1.4)	0.25	2.7 (± 1.0)	2.9 (± 1.0)	0.42
Salty	3.0 (± 1.1)	2.8 (± 1.1)	0.52	2.7 (± 1.1)	3.1 (± 1.1)	0.12
Bitter	2.6 (± 1.3)	3.3 (± 1.0)	0.05	3.5 (± 1.0)	3.5 (± 0.7)	0.86
TTS	11.4 (± 2.2)	12.0 (± 2.3)	0.48	12.3 (± 2.5)	13.0 (±2.2)	0.20
Age range						
41-50 y	n = 29	n = 27		n = 20	n = 12	
Sweet	3.2 (± 1.0)	3.5 (±0.6)	0.35	3.2 (± 0.9)	3.3 (± 0.8)	0.55
Sour	2.5 (± 1.1)	2.4 (± 0.9)	0.78	2.8 (± 0.8)	2.9 (± 0.9)	0.70
Salty	2.5 (± 1.2)	2.9 (± 1.3)	0.27	3.0 (± 1.1)	3.5 (± 1.0)	0.20
Bitter	2.3 (± 1.5)	3.0 (± 1.3)	0.08	3.4 (± 0.9)	3.1 (± 1.2)	0.40
TTS	10.6 (±3.5)	11.7 (±2.5)	0.18	12.4 (± 2.4)	12.8 (±1.9)	0.59

We did not find statistically significant differences in the gustatory function of PLHIV and healthy adults. The mean TTS for male PLHIV was 10.96 ± 2.99, and 11.80 ± 2.37 for healthy males (t = 1.58, P = 0.12). Likewise, among women, the mean TTS for female PLHIV was 12.33 ± 2.12 and 12.98 ± 2.12, for healthy females (t = 1.42, p = 0.16).

DISCUSSION

We investigated the olfactory and gustatory function of adult PLHIV on ART and healthy adults. PLHIV belonged to HIV stages 1, and 2, and were on ART. Thus, they did not present major health challenges. To the best of our knowledge, this is the first study conducted to assess the olfactory and gustatory function of adult PLHIV in Malawi and the third undertaken in a sub-Saharan African country.

In agreement with other studies, our data suggest that PLHIV suffer from olfactory deficits (Brody et al., 1991; Fasunla et al., 2016; Fasunla et al., 2018; Hornung et al., 1998; Zucco & Ingegneri, 2004). Our results also suggest that among PLHIV 18-35 years, OT were more affected than OD and OI abilities. Lower OT compared to OD and OI among PLHIV have also been reported by Mueller and colleagues (Mueller et al., 2002). In our study, the mean OT scores of male and female PLHIV 18-35 years were 5.6, and 6.3, respectively. Therefore, their mean scores were below the 10th percentile of the normative data, i.e., < 6.0 for males and < 6.5 females (T Hummel et al., 2007). Low OT suggest an affection of the peripheral nervous system, specifically of the olfactory receptor cells in the olfactory mucosa and/or the olfactory nerve (Lundström, Boesveldt, & Albrecht, 2010).

For PLHIV aged 36-50 years, the OI ability was more affected than OT and OD. The mean scores from the male (OI = 9.4) and female (OI = 10.3) PLHIV were below the 10th percentile compared to the normative data for men (OI = 11.0) and women (OI = 12.0). A reduced ability to identify and discriminate odors among PLHIV has also been reported by other authors (Hornung et al., 1998; Mattes et al., 1995; Zucco & Ingegneri, 2004) suggesting that higher structures of the CNS involved in odor processing are affected in PLHIV.

Some of the anatomical structures involved in the representation of odors in the brain are the orbitofrontal cortex, insula, the hippocampus, and the amygdala. In these structures, almost uncountable representations of odors are formed (Lundström et al., 2010). OD and OI tasks also occur in these brain structures. Hence, low OD and OI scores may be related to damage of these odor processing centers. Autopsy studies conducted in PLHIV have indicated that the most affected structures by HIV and the inflammatory process in the brain are the orbitofrontal, and temporal cortex, the basal ganglia, the amygdala, and the hippocampus (Gabuzda, 1990). Moreover, some studies have pointed out that these anatomical structures may be affected at an early stage of HIV infection (Avdoshina, Bachis, & Mocchetti, 2013; Centner, Bateman, & Heckmann, 2013; Gabuzda, 1990).

However, in our study, the low mean scores obtained by PLHIV and healthy adults in the olfactory tests may also be explained by the considerable cognitive demand of the olfactory assessments. The majority of our participants were from low education level and were not used to perform activities requiring a long attention span. The time and effort that participants dedicated to the OT, OD, and OI assessments may have negatively influenced their performance leading to low scores that underestimate their olfactory function.

The participants needed ~70 minutes to complete the three olfactory assessments. The majority of them indicated being tired after the first assessment, i.e., OT. Furthermore, when conducting the identification test, we used seven odors with lower percentages of correct recognition than those recommended by Hummel and colleagues (Thomas Hummel et al., 1997). Using more familiar smells could have resulted in higher OI scores. Moreover, the fact that we combined odors from the extended odor identification test kit "16 purple" with odors from the validated odor identification test kit "16 blue", challenges the comparability of our OI test scores with those from the normative data. Despite the limitations above, it should be noted that PLHIV obtained lower olfactory scores than the healthy participants and that our findings are in agreement with other studies cited above.

Concerning the gustatory function, in line with other studies (Frasnelli et al., 2016; Mattes et al., 1995), we found that PLHIV do not tend to develop gustatory loss. Also, we did not find significant differences in the mean TTS of PLHIV and healthy participants. However, our results oppose the findings reported by Fasunla and colleagues (Forde, 2018) and Raja et al. (Raja et al., 2013) who found gustatory losses among PLHIV. The inconsistency of findings suggests that more research is needed to conclude whether or not PLHIV suffer from gustatory loss. Larger samples sizes may contribute to more robust results.

The reason why the majority of PLHIV was affected by olfactory dysfunction and not gustatory dysfunction is unclear. Better gustatory performance may be explained by better protection of the gustatory system from damages of different nature, including damages caused by diseases such as HIV. The gustatory system seems to have a guarding function for the body. Each taste appears to be adjusted to satisfy specific physiological needs, e.g., sweet and umami stimulate energy intake; salt helps to maintain the electrolyte balance; sour contributes to keeping the pH balance, and bitter helps to avoid the ingestion of toxins (Lundstrom, Boesveldt, & Albrecht, 2011). Because of these physiologic functions of the taste system, special protective mechanisms may have been developed to preserve the gustatory system for human survival. Also, the pathways for processing gustatory information differ from pathways

for processing olfactory information. Some of the olfactory pathways may be more vulnerable to damage than the gustatory pathways.

Another explanation for higher gustatory scores compared to olfactory scores might be that the gustatory system seems to be less complicated than the olfactory system. While the olfactory system involves a high demand of cognitive processing to form the representation of millions of odors, the sense of taste needs to form five primary taste representations, i.e., sweet, sour, salty bitter and umami (Lundstrom et al., 2011). We did not observe that the participants encountered difficulty in taking the gustatory test. Less cognitive effort required from the participants may have led to higher scores, more robust and trustworthy results.

CONCLUSIONS

The evidence on the chemosensory function of PLHIV is inconsistent. The different methods used to assess the olfactory and gustatory function of people and the different cut-off points to define chemosensory dysfunction may explain such inconsistencies. In our study, we assessed the olfactory and gustatory function of adult PLHIV. Due to the difficulty that the participants experience while taking the olfactory tests, our results should be interpreted with caution. Yet, our findings suggest that PLHIV have a tendency to develop hyposmia, but not hypogeusia. More research is needed to conclude whether or not PLHIV suffer from olfactory loss and to estimate the magnitude of the affection.

ACKNOWLEDGMENTS

The authors would like to thank The St. Louis Nutrition Project team for supporting them with logistics and key contacts for setting up this study in Chilomoni clinic, Blantyre, Malawi. The authors are also thankful to Dr. Chrissie THakwalakwa from the College of Medicine of the University of Malawi for facilitating the recruitment of our team of field researchers and for supporting us with getting the ethical clearance for the conduct of the present study. The authors are also grateful with the World Food Programme Country Office in Malawi for the logistic support related to the import, and storage of the Sniffin' Sticks and Taste Strips.

References

Avdoshina, V., Bachis, A., & Mocchetti, I. (2013). Synaptic dysfunction in human immunodeficiency virus type 1 positive subjects: inflammation or impaired neuronal plasticity? *Journal of internal medicine, 273*(5), 454-465.

Boesveldt, S., & de Graaf, K. (2017). The differential role of smell and taste for eating behavior. *Perception, 46*(3-4), 307-319.

Braimah, O. E., & Onyeagwara, N. C. (2019). Olfactory identification in HIV positive adults living in Benin city, Nigeria. *International Journal of Otorhinolaryngology and Head and Neck Surgery, 5*(3), 537.

Brody, D., Serby, M., Etienne, N., & Kalkstein, D. S. (1991). Olfactory identification deficits in HIV infection. *Am J Psychiatry, 148*(2), 248-250.

Centner, C. M., Bateman, K. J., & Heckmann, J. M. (2013). Manifestations of HIV infection in the peripheral nervous system. *The Lancet Neurology, 12*(3), 295-309.

Fasunla, A. J., Daniel, A., Nwankwo, U., Kuti, K. M., Nwaorgu, O. G., & Akinyinka, O. O. (2016). Evaluation of Olfactory and Gustatory Function of HIV Infected Women. *AIDS research and treatment, 2016*.

Fasunla, A. J., Nwankwo, U., Adebayo, A. M., & Nwaorgu, O. G. (2018). Association between Sex, CD4 Cell Counts, Antiretroviral Medications, and Olfactory and Gustatory Functions of HIV-Infected Adults. *Otolaryngology–Head and Neck Surgery, 158*(1), 90-99.

Forde, C. G. (2018). From perception to ingestion; the role of sensory properties in energy selection, eating behaviour and food intake. *Food Quality and Preference, 66*, 171-177.

Frasnelli, J., Lague-Beauvais, M., LeBlanc, J., Alturki, A., Champoux, M., Couturier, C., . . . Tinawi, S. (2016). Olfactory function in acute traumatic brain injury. *Clinical neurology and neurosurgery, 140*, 68-72.

Gabuzda, D. H. (1990). Neurologic disorders associated with HIV infections. *Journal of the American Academy of Dermatology, 22*(6), 1232-1236.

Gobba, F. (2003). Occupational Exposure to Chemicals and Sensory Organs: A Neglected Research Field. *NeuroToxicology, 24*(4–5), 675-691. doi:http://dx.doi.org/10.1016/S0161-813X(03)00038-X

Henn, I. W., da Silva, R. O. C., Chaiben, C. L., Fernandes, Â., Naval Machado, M. Â., & de Lima, A. A. S. (2017). Perception of taste in HIV-positive individuals in treatment antiretroviral: results of a case-control study. *Special Care in Dentistry, 37*(1), 3-9.

Hornung, D. E., Kurtz, D. B., Bradshaw, C. B., Seipel, D. M., Kent, P. F., Blair, D. C., & Emko, P. (1998). The olfactory loss that accompanies an HIV infection. *Physiology & behavior, 64*(4), 549-556.

Howell, J., Costanzo, R. M., & Reiter, E. R. (2018). Head trauma and olfactory function. *World J Otorhinolaryngol Head Neck Surg, 4*(1), 39-45. doi:10.1016/j.wjorl.2018.02.001

Hummel, T., Kobal, G., Gudziol, H., & Mackay-Sim, A. (2007). Normative data for the "Sniffin'Sticks" including tests of odor identification, odor discrimination, and olfactory thresholds: an upgrade based on a group of more than 3,000 subjects. *European Archives of Oto-Rhino-Laryngology, 264*(3), 237-243.

Hummel, T., Sekinger, B., Wolf, S. R., Pauli, E., & Kobal, G. (1997). 'Sniffin'sticks': olfactory performance assessed by the combined testing of odor identification, odor discrimination and olfactory threshold. *Chemical senses, 22*(1), 39-52.

Landis, B. N., Welge-Luessen, A., Bramerson, A., Bende, M., Mueller, C. A., Nordin, S., & Hummel, T. (2009). "Taste Strips" - a rapid, lateralized, gustatory bedside identification test based on impregnated filter papers. *J Neurol, 256*(2), 242-248. doi:10.1007/s00415-009-0088-y

Landis, B. N., Welge-Luessen, A., Brämerson, A., Bende, M., Mueller, C. A., Nordin, S., & Hummel, T. (2009). "Taste Strips"–a rapid, lateralized, gustatory bedside identification test based on impregnated filter papers. *Journal of neurology, 256*(2), 242.

Lundstrom, J. N., Boesveldt, S., & Albrecht, J. (2011). Central Processing of the Chemical Senses: an Overview. *ACS Chem Neurosci, 2*(1), 5-16. doi:10.1021/cn1000843

Lundström, J. N., Boesveldt, S., & Albrecht, J. (2010). Central processing of the chemical senses: an overview. *ACS chemical neuroscience, 2*(1), 5-16.

Mattes, R. D., Wysocki, C. J., Graziani, A., & Macgregor, R. R. (1995). Chemosensory function and diet in HIV-infected patients. *The Laryngoscope, 105*(8), 862-866.

Mueller, C., Temmel, A., Quint, C., Rieger, A., & Hummel, T. (2002). Olfactory function in HIV-positive subjects. *Acta oto-laryngologica, 122*(1), 67-71.

World Health Organization (2005). *Interim WHO clinical staging of HVI/AIDS and HIV/AIDS case definitions for surveillance: African Region*. Retrieved from

Raja, J. V., Rai, P., Khan, M., Banu, A., & Bhuthaiah, S. (2013). Evaluation of gustatory function in HIV-infected subjects with and without HAART. *Journal of Oral Pathology & Medicine, 42*(3), 216-221.

Rolls, B. J. (1999). Do chemosensory changes influence food intake in the elderly? *Physiology & behavior, 66*(2), 193-197.

Seo, H.-S., & Hummel, T. (2009). Effects of olfactory dysfunction on sensory evaluation and preparation of foods. *Appetite, 53*(3), 314-321.

Welch, B. L. (1947). The generalisation of student's problems when several different population variances are involved. *Biometrika, 34*(1-2), 28-35.

Zucco, G. M., & Ingegneri, G. (2004). Olfactory deficits in HIV-infected patients with and without AIDS dementia complex. *Physiology & behavior, 80*(5), 669-674.

Chapter 5

Perception and acceptability of a fortified drink for preventing and treating mild to moderate undernutritionamong Malawian adults and adults living with HIV

Santiago Rodas-Moya
Cees de Graaf
Saskia de Pee
Mark Manary
Betina Piqueras-Fiszman

Under revision (Food Quality and Preference Journal)

ABSTRACT

In Malawi, malnutrition and HIV coexist and may lead to rapid weight loss -a predictor of mortality among people living with HIV (PLHIV). In resource-limited settings, ready-to-use therapeutic foods (RUTF) are often used to restore the nutritional status of adult PLHIV, however, the intense sweet flavor and high oil content of RUTFs may limit their intake, thereby limiting efficacy. We developed eight different samples of a nutritious drink comparable to Maheu, a regularly consumed beverage in Malawi. One-hundred PLHIV and 98 healthy adults aged 18-49 y. evaluated the samples in Blantyre, Malawi. We used hedonic scales for assessing liking, and CATA (check-all-that-apply) questions to develop a sensory characterization of the samples. Participants were also requested to describe the characteristics of their ideal beverage. Analysis of variance was employed to study significant differences in the acceptability of the products. Correspondence analysis was carried out to elaborate perceptual maps of the samples. Penalty analysis was conducted to identify the drivers of liking and disliking of the samples for subsequent product optimization. We found clear and significant differences in the acceptability of the samples, but no significant differences in preferences between PLHIV and healthy adults. The samples were also characterized similarly by the two groups. A preference toward sweet, somewhat sour, thick drinks with a soft texture and a milky flavor emerged. Developing a highly acceptable therapeutic food tailored to specific populations can contribute to maintaining adherence and increasing efficacy of nutritional interventions.

INTRODUCTION

Worldwide, an estimated 36.9 million people are living with HIV. Western and Southern Africa bears the highest burden of the epidemic with 19.6 million people affected. In Malawi alone, with a population of approximately 13 million people, about one million are HIV-positive (UNAIDS, 2018). People living with HIV (PLHIV) need to consume nutrient-dense foods to cover their increased energy and nutrient requirements. Asymptomatic and symptomatic PLHIV require 10% and 20-30% more energy than HIV-negative adults, respectively. In both PLHIV and healthy adults, protein should constitute 12%–15% of dietary intake and micronutrients should be consumed at the RNI (Recommended Nutrient Intake) level (WHO, 2004). Despite these recommendations, food insecurity in Malawi challenges people's access to food, particularly for PLHIV. In 2017, 52.4% of the population was food insecure, and 26.3% of the population was undernourished and suffered from chronic food deprivation (FAO, 2018).

Food insecurity, malnutrition, and HIV coexist and overlap geographically. The lack of access to nutritious foods combined with medical complications from untreated HIV infection and opportunistic illnesses result in insufficient consumption, absorption, and utilization of nutrients. As a consequence, the nutritional status of PLHIV deteriorates — challenging their immune system, increasing morbidity, and the risk of mortality (Weiser et al., 2011). A loss of 5% of body weight can increase the risk of death by 2.5 times, particularly among PLHIV who are not on antiretroviral therapy (ART) (Faintuch et al., 2006). In relation to this, food insecurity, the lack of nutritional support and undernutrition compromise the adherence to and success of ART, thereby worsening the cycle of undernutrition and PLHIV's health status (Young, Wheeler, McCoy, & Weiser, 2014).

In food-insecure settings, nutrient supplements are required to provide PLHIV, and other adults, with the nutrients they need to meet their requirements (Laurence Ahoua et al., 2011). In Malawi, ready-to-use therapeutic foods (RUTF), and sometimes corn-soy-blends (CSB) are often provided to treat undernutrition among adult PLHIV (Government of Malawi, Ministry of Health, 2006). Some studies have shown promising results for RUTF (J. R. Koethe, B. H. Chi, K. M. Megazzini, D. C. Heimburger, & J. S. Stringer, 2009; Ndekha et al., 2009). Despite these results, several barriers to RUTF acceptability among adults living with HIV have been reported, including: The disliking of its sensory characteristics (too sweet, too oily, somewhat salty) (Filippo Dibari et al., 2012; F. Dibari, P. Bahwere, et al., 2012; Mesrach Ayalew Kebede &

Jemal Haidar, 2014); the large portions indicated to treat severe and moderate undernutrition (i.e., 550 g/d and 270 g/day, respectively) Government of Malawi, Ministry of Health, 2006); the duration of treatment (4 months); and dietary monotony (F. Dibari, P. Bahwere, et al., 2012). These are some of the reported barriers for RUTF acceptability and adherence. An alternative nutrient supplement is required which can better overcome these barriers.

Based on formative research on the preferences for food and nutrient supplements conducted among PLHIV in Malawi (S. Rodas-Moya et al., 2016), we developed a nutritious drink similar to a frequently consumed beverage, i.e., "Maheu." Maheu is a fermented maize-based drink with a sweet and sour flavor and thick-grainy consistency. Beverages comparable to Maheu are also consumed in South Africa, Zambia, Mozambique, among other countries. A nutrient supplement similar to a widely consumed drink, such as Maheu, may be better accepted than traditional RUTFs, because its sensory attributes are familiar for consumers, and the sensory appraisal may be higher (Rozin & Vollmecke, 1986a).

To develop a palatable product, its sensory properties need to be adjusted to the preferences and expectations of the potential consumers. We aimed to develop a nutrient supplement for adults with undernutrition, in particular for PLHIV, and also, at a lower dosage, for adults at-risk of developing undernutrition. Hence, the present study was carried out with PLHIV and with adults from the general population. We included both population groups to investigate whether significant differences in perceptions and preferences toward the samples emerge. We used hedonic scales for assessing the liking and disliking toward the samples, and CATA (check-all-that-apply) questions to develop their sensory characterization (Gastón Ares, Dauber, et al., 2014; Meyners et al., 2013). Penalty analysis based on responses of the participants to the CATA questions was conducted to generate recommendations for optimizing up to three samples of the nutritious drink. It has been demonstrated that data from CATA questions generated by consumers can produce stable configurations of samples, comparable to characterizations developed by trained assessors using classic descriptive techniques (Gastón Ares et al., 2015; G Ares & Jaeger, 2014; Lawless & Heymann, 2010). It has also been shown that penalty analysis is a useful data analysis technique to identify drivers for liking and disliking of products based on CATA responses from consumers (Gastón Ares, Dauber, et al., 2014). The objectives of this study were to assess the acceptability of eight different samples of a nutritious drink, to explore how PLHIV and healthy adults characterize the nutritious drink samples, and to identify directions for optimizing the sensory properties of one or more samples of the nutritious drink with input from the potential consumers.

MATERIALS AND METHODS

General overview

We requested that participants score their overall liking of eight different samples of a nutritious drink and answer a CATA questionnaire to describe the sensory properties of the samples, as well as the sensory properties of a hypothetical ideal beverage with sensory properties comparable to those of Maheu. The CATA questionnaire included questions on flavor, odor, texture, hedonic appraisal, and health-related questions. The study followed a full crossover design (i.e., each participant assessed all products in a sequential monadic presentation). Analysis of variance was conducted to explore significant differences in the acceptability of the samples. Correspondence analysis (CA) was used to create sensory maps of the products, based on the CATA terms, and to visualize similarities and differences between products. Multiple factor analysis for contingency tables (MFACT) was used to explore differences in the way in which participants characterized the samples. Penalty analysis was undertaken to identify directions for optimizing the nutritious drink samples.

Participants

We invited 100 PLHIV and 98 healthy adults to participate in the study. A sample size of 100 participants is sufficient to generate stable configurations of samples and descriptors when using CATA questions for characterizing the sensory profiles of products (G Ares & Jaeger, 2014). Likewise, a sample size of 100 participants is sufficient when conducting consumer acceptability studies using hedonic scales (Lawless & Heymann, 2010). Male and female participants aged 18-49 years with a body mass index (BMI) $\geq$ 17 kg/m^2 and $<$ 25.00 kg/m^2 were included in the study. This BMI range was chosen because the nutritious drink is designed to treat mild to moderate undernutrition or to prevent undernutrition among consumers at risk of malnutrition, but with a normal body weight. Among PLHIV, participants enrolled in ART and belonging to clinical stages 1, and 2 (defined by the World Health Organization) (WHO, 2016) were included. PLHIV from clinical stages 1 and 2 may not experience the major health challenges that could potentially impair them from consuming and evaluating the samples. The participants were contacted by the Health Surveillance Assistants (HSAs) of Chilomoni Clinic in Blantyre. The HSAs are government employees that perform health promotion activities at the Chilomoni clinic and in rural communities near Chilomoni, in Blantyre. PLHIV were contacted at Chilomoni clinic. The healthy adults were contacted at their households.

Data collection team

We trained a team of five field researchers with university degrees to collect the data. The field researchers have worked in previous research projects with us for 2+ years, and in other research projects before. They were fully bilingual in English and Chichewa, the local language. The field researchers received training for two weeks. The training included eight days of practice at Chilomoni Clinic with participants of similar socioeconomic characteristics to those of the study population.

Samples

The nutritious drink is a fortified product developed in the form of a powder that needs to be reconstituted with clean water at room temperature. The resulting beverage has sensorial characteristics comparable to Maheu. The nutritious drink is made of corn and soybean flours, fully processed with wet extrusion cooking to reach the desired sensory properties. It also has milk and milk derivatives, maltodextrin, and sugar. The macro and micronutrient composition of the nutritious drink is presented in the Appendix. One portion of the nutritious drink (100 g of powder) can be consumed for preventing undernutrition among adults. To treat moderate acute undernutrition (BMI ≥ 17 kg/m^2 and < 18.5 kg/m^2) among PLHIV, two portions (200 g of powder) of ~250 ml each consumed twice a day is the target. Two portions provide ~740 kcal and ~80% of the micronutrients required from a 2500 kcal diet for treating undernutrition (22) (Appendix). We developed eight samples of the nutritious drink with different levels of sweetness, sourness, and thickness, in addition to flavored and unflavored versions. Table 5.1 presents the factors that were modified to achieve different sensory properties.

Table 5.1. Ingredients used to develop eight samples of the nutritious drink with different sensory profiles.

Samples	Dextrose (g)	Lactic acid (g)	Water (ml)	Flavor[1] (g)
I	17	3	130	0
II	23	3	130	0.08
III	23	4.5	130	0
IV	17	4.5	130	0.08
V	17	4	180	0
VI	23	3.5	180	0.08
VII	23	5	180	0
VIII	23	5	180	0.08

[1] The flavor mix contains beer, milk, honey, and apple flavor.

Experimental procedure

The study was conducted in a central location test (CLT) area at Chilomoni Clinic. Individual sensory booths were arranged in a well-ventilated and illuminated room free of noise and extraneous odors. The samples were prepared in an area isolated from the test room 10 minutes before starting the tests.

To prepare the samples, we used branded bottled water at room temperature (~25°C). Twenty ml of each sample was served in a 25 ml translucent plastic cup labeled with 3-digit codes. The samples were served to participants in a monadic sequence following a full randomized complete block design balanced for carry-over and position effects (Lawless & Heymann, 2010; Williams, 1949). We requested that the participants indicate their liking for the samples using a horizontal pictorial 7-point hedonic scale with smileys and anchors - "I dislike very much" on the left, and "I like very much" on the right. After rating a product, the participants were requested to complete a CATA questionnaire with 26 attributes. We obtained those attributes from a previous open-ended question study (unpublished) that aimed at assessing perceptions of the eight samples of the nutritious drink. The open-ended question study was also conducted at Chilomoni clinic with Malawian participants of similar sociodemographic characteristics.

Because the majority of participants had high school education level, to facilitate the use of the CATA questionnaire, we grouped the attributes into sensory (smell, flavor, and texture), hedonic and health-related characteristics. The attributes were presented following the same order to all participants. After they tasted the eight samples, we requested that the participants complete a sociodemographic questionnaire. The questionnaires were first developed in English, translated from English to Chichewa, and back-translated into English to check the accuracy of the translation. Minor adjustments were made to the final version.

This study was conducted according to the guidelines of the Declaration of Helsinki and all procedures involving human subjects were approved by the College of Medicine Research and Ethics Committee (COMREC) from Malawi, registration number P.04/17/2158.

Data analysis

Analysis of variance

An analysis of variance was performed on the overall liking scores considering "product," "HIV status," and its interactions as explanatory variables. The least significant difference (LSD) test was used to identify the best product (Le & Worch, 2014).

CATA counts and correspondence analysis

To analyze the CATA data, we calculated the frequency of use of each attribute by counting the number of participants that ticked each attribute to describe a specific sample. Contingency tables were built with frequency data allocating the samples in columns and attributes in rows. We used the Cochran's Q test (G Ares & Jaeger, 2015) to identify significant differences between samples. Correspondence analysis (CA) with Hellinger distances (Meyners et al., 2013) was conducted to visualize the data from the contingency tables on bi-dimensional plots.

Multiple factor analysis for contingency tables

Multiple factor analysis for contingency tables (MFACT) was carried out (G Ares & Jaeger, 2015; Le & Worch, 2014) to investigate the relationship between responses to the CATA questionnaire from PLHIV and healthy adults. The contingency table of each group of participants was considered as a separate group of variables in the analysis. The RV coefficient between the configurations of PLHIV and healthy adults was also calculated. The RV coefficient is a numerical indicator used to assess the strength of the relationship of two configurations (0 indicates that the configurations are entirely different; 1 indicates that the configurations are identical).

Penalty analysis

Penalty analysis was undertaken with data from the liking scores and CATA data from the real products and the hypothetical ideal product (Meyners et al., 2013). We first determined whether an attribute was used only for the ideal (I) or only for the real (R) product, i.e., (I-1; R-0) or (I-0; R-1). This situation was defined as incongruent. If an attribute was used for the ideal and real product, i.e. (I-1, R-1), or not used for the ideal nor for the real product, i.e. (I-0, R-0), the situation was defined as congruent. We then determined the difference in mean

liking per attribute for consumers with a congruent and incongruent selection of attributes, e.g., [(I-1, R-1) - (I-1, R-0)]. Mean drops in liking between the two situations were obtained for each attribute, and their significance was tested. A significant increase in liking scores from the case (I-1, R-1) over the case (I-1, R-0) results in a "must-have" attribute. From the congruence (I-0, R-0) over the incongruence (I-0, R-1) and when a significant decrease in liking occurs, "must-not-have" attributes are derived. On the contrary, when from the situation (I-0, R-0) over (I-0, R-1), a significant increase in liking is observed, a "nice-to-have" attribute is obtained. The "must-have"; "must-not-have" and "nice-to-have" attributes with significant impact on mean liking scores were displayed in mean impact charts.

Data were analyzed in R Version 1.1.419 with the packages, SensoMineR, FactoMineR, Factoextra, agricolae, and DoBy. The correspondence analysis with Hellinger distances and penalty analysis were conducted in EXCELSTAT-Sensory.

RESULTS

In total, 198 participants evaluated the samples. Their sociodemographic and health characteristics are presented in Table 5.2.

Table 5.2. Sociodemographic and health characteristics of PLHIV and healthy adults.

Characteristics	**PLHIV**	**Healthy adults**
	n=	n=
Age (in years)	33.4 ± 8.3	33.9 ± 8.3
Gender		
Male	57	50
Female	43	48
ART regime		
2A[1]	4	NA
5A[2]	96	NA
BMI categories		
(17-<18.5 kg/m2)	7	2
(≥18.5 to 24.99 kg/m2)	93	96
Smoking status		
Yes	0	1
No	100	97

Monthly income (MWK[3])		
0-6000	21	13
6001-12000	74	25
>12000	5	60
Education		
Primary school	8	6
High school	84	77
More than High school	8	15

Values are expressed as mean ± SD, and in absolute numbers of participants.
[1]2A Zidovudine 300 mg; lamivudine 150 mg; nevirapine 200 mg
[2] 5A Tenofovir disoproxil fumarate 300 mg; lamivudine 300 mg; efaviren 600 mg
[3]USD 1 = MWK 740 Malawian Kwacha (MWK)

Overall liking scores

We found significant differences in the overall liking scores of the nutritious drink samples in both groups, i.e., PLHIV [$F(7) = 20.4$, $p < 0.0001$] and healthy adults [$F(7) = 22.3$, $p < 0.0001$]. However, substantial differences in preferences between PLHIV and healthy adults were not found [$F(1)= 2.81$, $p = 0.09$]. Also, we did not find interactions between HIV status and the liking scores of samples [$F(7)=0.94$, $p = 0.47$]. The average liking scores of the samples were calculated as mean ± SD and ranged from 3.6 ± 2.3 to 5.9 ± 1.7; and 3.7 ± 1.9 to 6.0 ± 1.5 among PLHIV and healthy adults, respectively (Table 5.3).

Table 5.3. Mean liking scores of eight samples of the nutritious drink with different sensory profiles granted by PLHIV and healthy adults.

Participants		**Samples**							
		I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**
PLHIV	Mean	4.7^{bc}	5.8^{a}	4.3^{c}	3.6^{d}	5.9^{a}	5.0^{b}	4.4^{c}	5.7^{a}
	SD	2.1	1.7	2.0	2.3	1.7	1.9	2.2	1.6
Non_HIV	Mean	4.8^{d}	5.3^{bc}	4.0^{e}	3.7^{e}	6.0^{a}	4.8^{cd}	3.8^{e}	5.7^{ab}
	SD	2.0	1.9	2.0	1.9	1.5	1.8	2.1	1.5

Products with the same superscript do not differ significantly according to Fisher´s LSD test.
Every pair of samples with a difference in the overall liking larger than 0.51 points (LSD = 0.51) is significant at 5% ($\alpha = 0.05$).

CATA counts and correspondence analysis: healthy adults

We found significant differences ($p < 0.05$) in the frequency with which the participants ticked 21 out of 26 attributes. This suggests that the samples were perceived differently (Table 5.4). The ideal beverage was primarily described with the attributes *appetizing, nutritious, energy-giving, filling, thick, smooth, good sweetness, milky flavor, Banana flavor, and good sourness.*

Table 5.4. Contingency table with the frequency of use of the CATA terms for eight samples of the nutritious drink and a hypothetical ideal Maheu: healthy adults.

Attributes	p-values[1]	Samples								
		I	II	III	IV	V	VI	VII	VIII	Ideal[2]
Nutty smell	0.133	31	21	25	17	24	18	20	20	2
Soy smell	0.000	33	9	21	17	18	9	16	13	4
Banana smell	0.111	7	20	10	13	17	17	13	15	33
Strawberry smell	0.355	5	7	6	8	7	8	7	14	18
Nutty flavor	0.056	18	18	20	8	21	17	13	11	3
Strawberry flavor	0.001	1	14	6	6	6	5	6	15	24
Soy flavor	0.000	38	16	16	18	14	14	17	10	4
Banana flavor	0.000	10	24	6	6	17	18	13	17	43
Milky flavor	0.000	69	71	52	47	76	59	48	69	89
Not sweet	0.000	34	17	51	60	14	38	61	18	2
Good sweetness	0.000	60	68	44	34	76	54	33	75	91
Too sweet	0.000	0	11	0	0	8	2	1	4	1
Good sourness	0.000	63	67	26	16	58	42	13	38	52
Too sour	0.000	31	31	59	63	33	49	61	54	39
Beer flavor	0.000	14	19	31	52	14	25	37	34	2
Aftertaste	0.332	48	59	53	55	59	55	63	55	0
Thick	0.000	92	91	91	92	62	60	74	74	88
Liquid	0.000	4	0	5	6	35	35	21	24	10
Rough	0.000	40	38	42	62	26	31	39	30	1
Smooth	0.000	57	60	55	36	72	66	57	67	97
Soft grains	0.000	42	50	41	61	43	57	62	47	63
Hard grains	0.000	5	8	13	12	0	2	6	2	0
Appetizing	0.000	69	86	61	48	85	67	53	77	98
Nutritious	0.000	84	92	85	76	91	82	78	80	98
Gives energy	0.028	91	96	90	86	93	89	84	90	98
Filling	0.048	92	92	91	87	91	82	84	88	98

[1] Cochran's Q p-values

[2] The Ideal Maheu was omitted for the Cochran's Q test, which was used to explore differences between real products.

The correspondence analysis (CA) is presented in Figure 5.1.

Axes Dimension 1 and Dimension 2: (75.80 %)

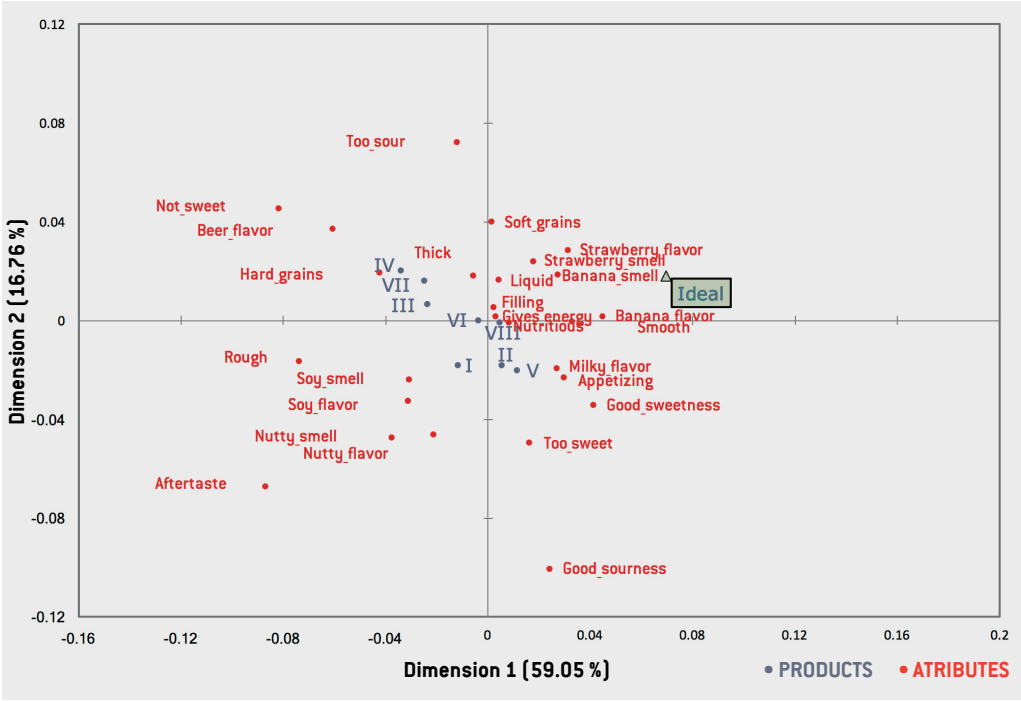

Figure 5.1. Representation of the eight samples of the nutritious drink and the Ideal Maheu with attributes from the CATA counts in the first and second dimensions of the correspondence analysis plot: data from healthy adults.

Dimensions 1 and 2 explain 59% and 16.8% of data variability, respectively. CA shows that the eight samples of the nutritious drink are distributed in three groups (Figure 5.1). The samples with the highest liking scores—V, VIII, and II—are located at the positive values of dimension 1 and negative values of dimension 2, and were mainly described with the attributes *appetizing, nutritious, good sweetness, milky flavor, and smooth texture.* Sample V obtained the highest liking score. It contained 17 g of dextrose, 4 g of lactic acid, no flavor mix, and it was prepared with 180 ml of water.

Samples III, IV, and VII are located at the negative values of dimension 1 and positive values of dimension 2. These are the samples with the lowest liking scores. Participants characterized them primarily as *too sour, not sweet, thick,* with *hard grains* and with *beer flavor*. Often, the attribute beer flavor was used to describe the samples with the highest content of lactic acid and the lowest content of dextrose. Sample IV obtained the lowest liking score. This sample

had 17 g of dextrose, 4.5 g of lactic acid, and the flavor mix. It had the lowest quantity of water, i.e., 130 ml.

The last group consists of samples I and VI. Sample I is located at negative values of dimensions 1 and 2. The attributes associated with sample I are *nutty, soy smell, soy flavor, and aftertaste*. Sample VI is located at negative values of dimension 1 and at the borderline of positive and negative values of dimension 2. The primary attributes used to characterize sample VI were a *nutty smell, milky flavor, banana flavor, nutritious, and aftertaste.* Sample VI had 23 g of dextrose, 3.5 g of lactic acid, and the flavor mixture. It was prepared with 180 ml of water.

The CA plot suggests that the primary discrimination between the three groups of samples was based on its sweetness, sourness, the milky flavor, and texture, i.e. soft vs. rough.

The Ideal product is located at positive values of dimensions 1 and 2. The ideal product was described as *appetizing, nutritious, filling, and energy giving.* It should have a *smooth texture,* a *milky flavor, good sweetness, and good sourness*, which seems to be close to the sweetness of sample V, i.e.~17 g of dextrose and sourness of sample II, i.e. ~3 g of lactic acid. The majority of participants ticked the strawberry and banana flavors more frequently as their favorite flavors for the ideal product. Product VIII, V, and II seem to share most of the characteristics of the ideal product, except banana and strawberry flavors.

Penalty analysis on CATA and liking data: healthy adults

When assessing the samples, the healthy adults focused primarily on flavor and texture. The "must-have" attributes identified through penalty analysis for the best product were *good sweetness, good sourness* (i.e., an adequately balanced *sweet and sour flavor*), *strawberry flavor, and banana flavor.* The "must-have" texture was *smooth*. Regarding the sweet and sour flavor, the liking data and the correspondence analysis plots suggest that an optimal sweet and sour balance may be achieved with ~3 g of lactic acid and ~17 g of dextrose. The attribute with the highest mean impact was *appetizing*. An appetizing product may be achieved with the attributes indicated above and by eliminating the "must-not-have" attributes, i.e., *rough* consistency, *beer flavor*, and a *low sweetness*. The impact charts displaying the "must-have," "must-not-have" and "nice-to-have" attributes are presented in figures 5.2 and 5.3.

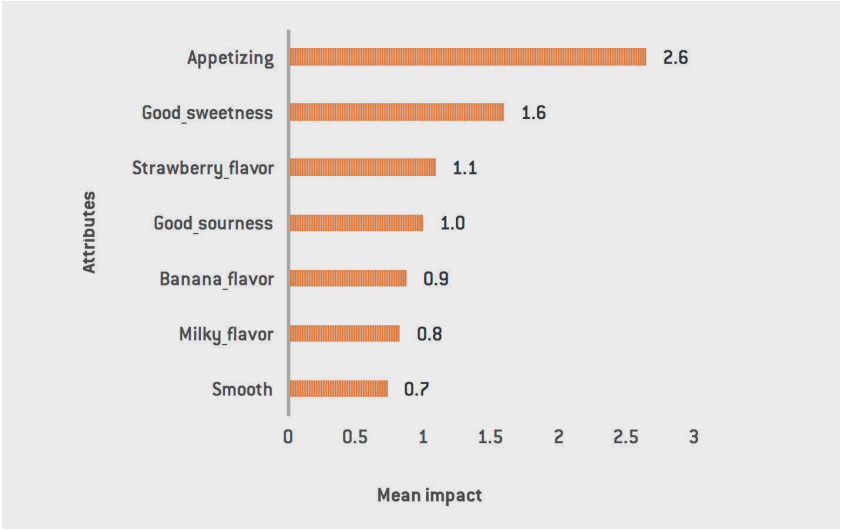

Figure 5.2. Mean impact chart showing attributes with significant mean increases representing the "must-have" attributes: data from healthy adults.

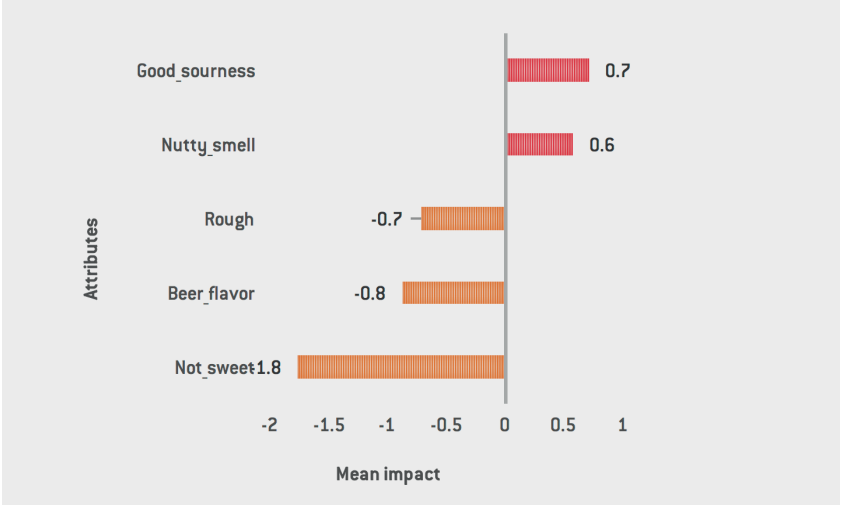

Figure 5.3. Mean impact chart showing attributes with significant mean impact. Significant mean increases are shown with red bars and represent "nice-to-have" attributes. Significant mean drops are shown with orange bars and represent "must-not-have" attributes: data from healthy adults.

CATA counts and correspondence analysis: PLHIV

We found significant differences ($p < 0.05$) in the frequency with which 19 out of 26 attributes were selected by PLHIV to describe the samples. This suggests that the participants perceived differences between the samples (Table 5.5).

Table 5.5. Contingency table with the frequency of use of the CATA terms for eight samples of the nutritious drink and a hypothetical ideal Maheu: PLHIV.

Attributes	p-values[1]	Samples								
		I	II	III	IV	V	VI	VII	VIII	Ideal[2]
Nutty_smell	0.013	40	29	38	23	38	27	29	27	2
Soy_smell	0.005	39	39	30	23	28	30	27	22	4
Banana_smell	0.101	17	24	19	25	20	30	17	27	45
Strawberry_smell	0.551	10	11	12	12	15	15	9	16	29
Nutty_flavor	0.089	26	22	26	19	29	22	14	28	2
Strawberry_flavor	0.082	6	11	13	14	16	13	8	17	29
Soy_flavor	0.002	40	38	29	25	32	24	25	20	6
Banana_flavor	0.032	23	22	15	13	18	24	11	19	49
Milky_flavor	0.001	73	84	76	68	84	76	69	83	90
Not_sweet	0.000	35	11	38	58	13	35	51	15	4
Good_sweetness	0.000	61	77	56	34	75	57	37	73	94
Too_sweet	0.000	0	6	1	1	10	0	63	6	0
Good_sourness	0.000	48	83	24	20	58	42	21	45	87
Too_sour	0.000	45	15	70	80	37	54	67	55	10
Beer_flavor	0.000	15	15	28	35	11	37	35	25	2
Aftertaste	0.549	48	54	60	58	56	56	57	58	0
Thick	0.000	90	93	96	93	75	68	74	67	88
Liquid	0.000	8	4	3	6	16	26	22	29	15n
Rough	0.182	30	25	30	38	24	31	33	25	1
Smooth	0.152	70	74	68	61	76	67	67	74	98
Soft_grains	0.581	41	44	43	42	40	47	43	35	64
Hard_grains	0.001	5	3	5	15	2	6	5	7	0
Appetizing	0.000	67	90	66	49	93	78	67	87	100
Nutritious	0.000	89	99	92	81	98	90	87	96	100
Gives_energy	0.003	93	99	96	87	97	91	91	96	100
Filling	0.025	96	97	96	89	97	90	93	93	99

[1] Cochran's Q *p*-values

[2] The Ideal Maheu was omitted from the Cochran's Q test, which was used to explore differences between the real products.

The attributes used by PLHIV to describe the ideal beverage were comparable to those used by the healthy adults. PLHIV primarily described the ideal beverage with the attributes *appetizing, nutritious, energy-giving, filling, smooth, thick, good sweetness, good sourness, milky flavor, and banana flavor.* The correspondence analysis is presented in figure 5.4.

Axes dimension 1 and dimension 2: (76.79 %)

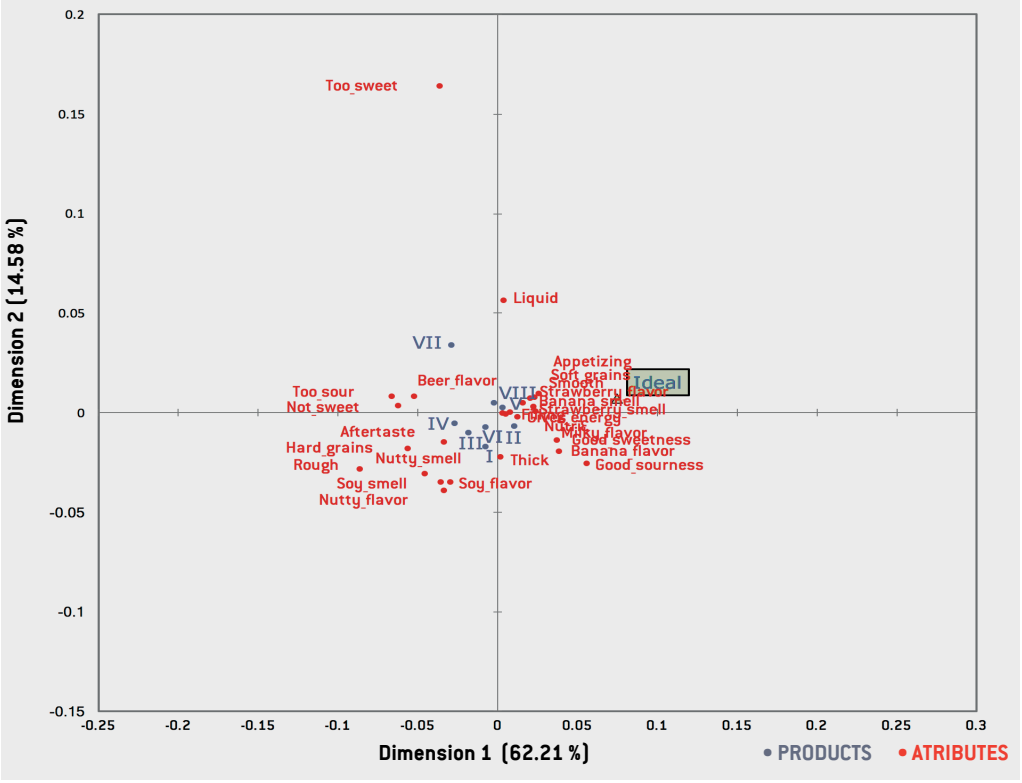

Figure 5.4. Representation of the eight samples of the nutritious drink and the Ideal Maheu with attributes from the CATA counts in the first and second dimensions of the correspondence analysis plot: data from PLHIV.

Dimensions 1 and 2 explain 62.2% and 14.6% of data variability, respectively. Together, dimensions 1 and 2 explain 76.8% of the variability of the data. The CA plot derived from the CATA data from PLHIV shows a superposition of attributes and short distances between products. Nonetheless, clear discrimination of attributes between the samples with higher and lower liking scores is observed.

In contrast with the CA plot from the healthy adults, in PLHIV's CA plot, the samples are distributed in different dimensions of the bi-dimensional plot. Although the samples with the highest liking scores—II, V, and VIII—are close

to each other, sample V is located at positive values of dimensions 1 and borderline values of dimension 2, closer to the positive values. Sample II is located at positive values of dimension 1 and negative values of dimension 2, and sample VIII is located at positive values of dimension 2 and at borderline values of dimension 1, closer to the negative values. In agreement with the healthy adults, the attributes used for characterizing samples II, V, and VIII were mainly *milky flavor, good sweetness, thick, smooth, appetizing, nutritious, energy-giving, filling, and good sourness.* However, among PLHIV, sample II, which contained 3 g of lactic acid was more frequently described as a product with a *good sourness* than samples V and VIII (Table 5.5). The CA plot also shows that samples II, V, and VIII shared the characteristics mentioned above with the ideal product.

Sample VII is located at the negative values of dimension 1 and positive values of dimension 2. Sample VII was primarily described with the attributes *beer flavor, too sour, and too sweet.* However, some PLHIV also frequently checked the attribute *not sweet* for this sample. Sample VII contained 23 g of dextrose and 5 g of lactic acid. The high sourness of sample VII may have led some participants to perceive that this sample was not sweet (n = 51), while its high sweetness may have led other participants to perceive that the sample was too sweet (n = 63). This inconsistency suggests that the sweet and sour balance of product VII is inadequate. The mean liking score of sample VII was 3.8. Hence, the attributes associated to sample VII seem to be the main drivers of disliking of the nutritious drink.

Samples III, IV, VI, and I are located at the negative values of dimensions 1 and 2. They were mainly described with the attributes *hard grains, rough, soy smell, nutty smell, soy flavor, nutty flavor, and aftertaste.* These samples had the lowest liking scores.

Penalty analysis on CATA and liking data: PLHIV

In line with the findings from the healthy adults, among PLHIV, the "must-have" attributes were also related to flavor and texture. For PLHIV, a good product must have the right sweet and sour balance, banana, and milky flavor, and it should be smooth. The attributes to avoid for a good product are excessive sourness, beer flavor, aftertaste, and roughness. The "must-have;" "must-not-have;" and "nice-to-have" attributes are presented in figures 5.5 and 5.6.

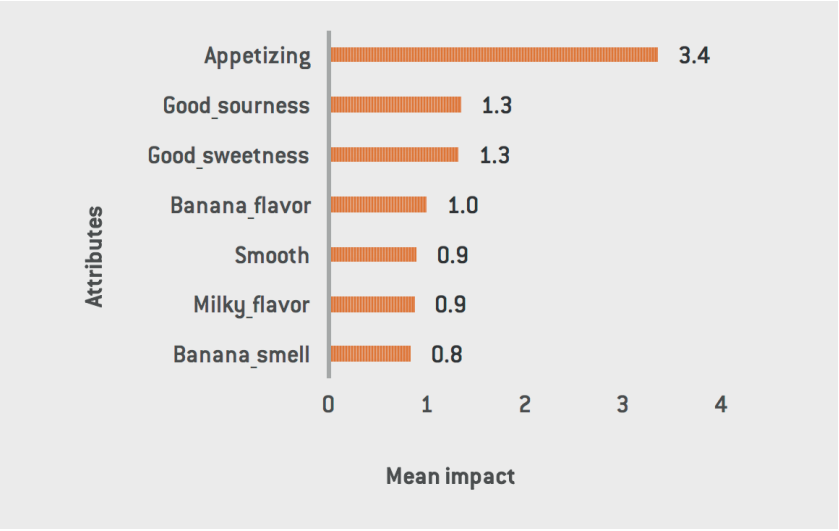

Figure 5.5. Mean impact chart showing attributes with significant mean increases representing the "must-have" attributes: data from PLHIV.

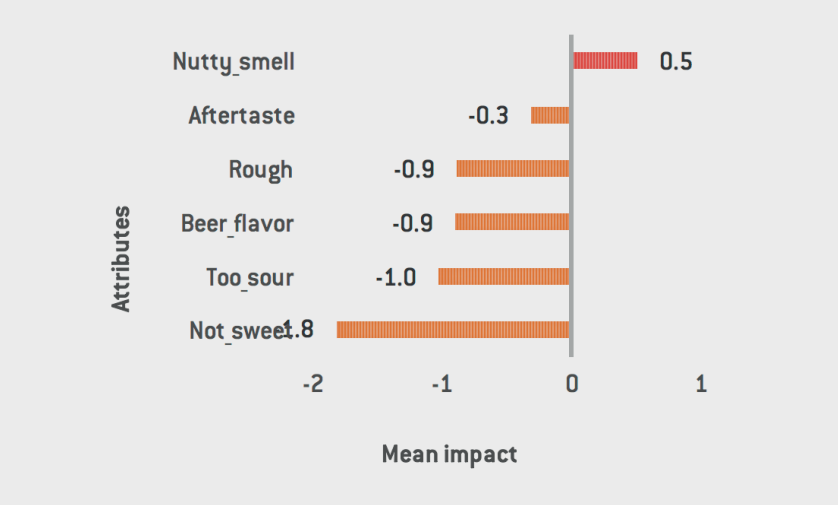

Figure 5.6. Mean impact chart showing attributes with significant mean impact. Significant mean increases are shown with red bars and represent "nice-to-have" attributes. Significant mean drops are shown with orange bars and represent "must-not-have" attributes: data from PLHIV.

The similarity in the "must-have" and "must-not-have" attributes between PLHIV and healthy adults suggests that similar modification to the nutritious drink may lead to higher acceptability of the product among both population groups.

Multiple factor analysis for contingency tables

The characterization of the samples in the first and second dimensions of the MFACT showed that PLHIV and the healthy adults described the samples similarly. The RV coefficient between samples' configuration for both population groups was 0.95, indicating a high level of agreement. The similar preferences may be explained by the fact that PLHIV and the healthy adults assessed the nutritious drink having a Maheu in mind for comparison. This could make them focus on specific sensory attributes that they considered relevant to judge the quality of the nutritious drink.

DISCUSSION

Using the results of formative research (S. Rodas-Moya et al., 2016), we developed eight samples of a nutritious drink with different sensory profiles. We manipulated the intensities of sweetness, sourness, as well as thickness. We also added a flavor mixture to four versions of the nutritious drink. The flavor mixture was added to provide the smell and flavor perception of fermentation, a property of Maheu, and to mask the soy flavor, an atypical ingredient in Maheu (soy was added to the nutritious drink to achieve a PDCAAS ≥ 75). The other four samples did not contain the flavor mixture. The soy flavor and smell were more perceptible from the unflavored samples. However, some participants also perceived a soy flavor and smell from the flavored versions of the nutritious drink, which suggest that the flavor mixture could not fully cover the soy flavor, neither its smell. When the participants described the flavors and scents of the nutritious drink samples, we also observed that some of them ticked the attributes nutty smell and nutty flavor. Nuts were not among the ingredients of the nutritious drink samples. It seems that soy was confounded with some nut, most probably with groundnuts, by some participants. Groundnuts are legumes with a nutty flavor and smell (S. Rodas-Moya et al., 2016). They represent one of the most important crops in Malawi (Derlagen & Phiri, 2019). Interestingly, the selection of the attributes soy and nutty smell/flavor occurred more frequent among PLHIV (tables 4 and 5).

In this study, we used state of the art methods of sensory and consumer science to investigate the perceptions of PLHIV and healthy adults toward the

eight samples of the nutritious drink, i.e. CATA questions combined with hedonic scales and the latest developments on statistical analysis for sensory data (Gaston Ares et al., 2010; G Ares & Jaeger, 2014; Gastón Ares, Tárrega, Izquierdo, & Jaeger, 2014; Meyners & Castura, 2014; Meyners et al., 2013). We identified samples with different levels of acceptability, specific sensory attributes that drive the liking and disliking toward the samples, and we generated guidelines to optimize the nutritious drink to the preferences of its potential consumers. To the best of our knowledge, this is the first study that uses these methods to develop a culturally adapted nutrient supplement with sensory characteristics tuned to the preferences of PLHIV and healthy adults in an African country.

Overall, we observed a preference for the samples with lower intensity of sourness, higher intensity of sweetness, a milky flavor, and smooth texture (samples V, VIII, and II). The sensory properties of samples II, V, and VIII were closer to the description of the hypothetical ideal Maheu. However, our results suggest that these products could increase their resemblance to an ideal Maheu if a banana flavor and strawberry flavor were added and if the intensity of the milky flavor was increased. Interestingly, traditional Maheu does not contain fruits. However, several industrially produced new Maheu drinks with different flavors have been placed into the market in Malawi in the last years. With respect to the milky flavor, in our formative research on preferences for food and nutrient supplements conducted in Malawi (S. Rodas-Moya et al., 2016), we found that consuming milk and milk products is associated with high socioeconomic status, an important aspirational driver for consumption. Furthermore, developing the nutritious drink with different flavors may also contribute to increasing dietary variety and may relieve monotony, which has been reported as a common barrier for the habitual consumption of nutrient supplements such as RUTF among adult PLHIV (F. Dibari, P. Bahwere, et al., 2012; Mesrach Ayalew Kebede & Jemal Haidar, 2014; M. F. Olsen et al., 2013). Table 5.6 summarizes the key recommendations for optimizing the nutritious drink.

Table 5.6. Directions for product optimization to develop three samples of the nutritious drink using sample V as a base product.

Base sample	Sweetness	Sourness	Flavor mix	Other flavors
Sample V prepared with 180 ml of water.	Use ≤ 17 g of dextrose.	Use ≤ 3 g of lactic acid.	Increase milk flavor, reduce or eliminate beer flavor while keeping the perception of early fermentation.	Use the base sample without the flavor mix and add banana flavor. Use the base sample without the flavor mix and add strawberry flavor.

We did not find significant differences in the acceptability of the samples between PLHIV and the healthy adults. The sensory characterization of the samples performed by both groups was also similar (RV = 0.95). The lack of significant differences between PLHIV and healthy adults in their preferences toward the samples of the nutritious drink may be explained by the fact that our product benchmarked Maheu, a drink that is part of the Malawian food culture. The sensory preference of food and drink depends heavily on culture and tradition, which determine how foods and beverages should ideally be (Luis Cantarero, Espeitx, Gil Lacruz, & Martín, 2013; Rozin & Vollmecke, 1986a). The participants in this study were asked to assess the nutritious drink samples with an ideal Maheu in mind, and they were trying to identify characteristics that could make the nutritious drink more similar to the Maheu of their preference.

The health conditions of PLHIV may be another reason that explains the lack of differences in preference toward the products. In this study, the HIV-positive participants did not have major health challenges that could potentially affect their preferences for food or drinks. PLHIV from more advanced HIV stages and with co-existing illnesses may have different preferences (S. Rodas-Moya et al., 2016; Santiago Rodas-Moya et al., 2017). Nevertheless, the nutritious drink is a product to prevent and treat mild to moderate undernutrition among people without major health challenges, and with a home-based approach. It is not a product for treating undernourished PLHIV with severe health challenges who may need to be treated in a health care facility under medical supervision.

Concerning methodological aspects, we observed that the participants did not experience difficulty using the questionnaires for data collection, i.e., the pictorial 7-point hedonic scales and the CATA questionnaire. Ares and colleagues also indicated that the CATA method is easy to use by untrained consumers (Gastón Ares et al., 2015; Gastón Ares, Dauber, et al., 2014). Moreover, the fact that we used attributes from a previous open-ended question study to develop the CATA questionnaire may have also facilitated the use of the CATA questionnaire by the participants of this study because the attributes may have been familiar to them.

The contingency table and correspondence analysis also show that the participants could perceive clear differences between the products. This suggests that the CATA method was suitable for developing sensory profiles of products using consumers from a low-income and low education level in Malawi. In addition to this, the penalty analysis led to clear recommendations for product optimization. Based on the results of the present work, we believe that the methods for data collection and analysis used for developing the

nutritious drink may also be suitable for developing other products with input from untrained consumers from low-income and low education levels in Malawi and other African countries.

In this study, we used a taste-and-swallow test with 20 ml samples and a single exposure. A drawback of this approach is that the participants assessed the samples based on brief sensorial exposure. The nutritious drink is a complex fortified product with high nutrient and caloric densities, which may make it more satiating than a regular Maheu. Thus, the liking toward the nutritious drink may have changed with the ingestion of a larger quantity of the product and with repeated exposure (de Graaf et al., 2005). Studying the acceptability of the nutritious drink using an ad libitum consumption approach may be an alternative to investigating whether participants can consume large portions of the nutritious drink, e.g, > 250 ml while keeping high acceptability for the drink. Furthermore, higher correlation coefficients between liking scores and long term consumption have been reported when liking is assessed based on an ad libitum intake approach than with taste-and-swallow tests ($r = 0.81$ and $r = 0.62$, respectively) (Zandstra, de Graaf, van Trijp, & van Staveren, 1999). Thus, future research should focus on testing the acceptability of the nutritious drink using an ad libitum consumption approach. Comparing the ingestion of the nutritious drink with nutrient supplements such as RUTF and CSB can elucidate which of the products are consumed more and therefore may lead to greater adherence and ultimately higher efficacy.

CONCLUSIONS

We investigated the perceptions and acceptability of eight different samples of a nutritious drink among PLHIV and healthy adults. Between the two groups, no significant differences in preference toward the samples emerged, and their sensorial characterization was comparable. A preference toward sweet, slightly sour samples with a milky flavor and a soft texture emerged. Penalty analysis provided clear directions for further optimization of the nutritious drink, which may contribute to increasing the reward value of the product. Due to its high acceptability and nutrient composition, a tailored nutritious drink based on the results of this study could be used to treat malnutrition, and also to support the nutrition and health status of PLHIV and healthy adults in Malawi and other sub-Saharan African countries. Future research should focus on the acceptability of ad libitum consumption of the nutritious drink with the highest acceptance rating in comparison to the nutrient supplements RUTF and CSB.

ACKNOWLEDGMENTS

The authors would like to thank The St. Louis Nutrition Project team for supporting them with logistics and key contacts for setting up this study in Malawi. The authors are also thankful with the College of Medicine of the University of Malawi for facilitating the recruitment of a great team of field researchers and granting ethical clearance for the conduct of the present study. The authors are also grateful with the World Food Programme Country Office in Malawi for their logistic support related to the import, and storage of the nutritious drink samples from South Africa and with DSM for developing the nutritious drink Samples.

References

Ahoua, L., Umutoni, C., Huerga, H., Minetti, A., Szumilin, E., Balkan, S., et al. (2011). Nutrition outcomes of HIV-infected malnourished adults treated with ready-to-use therapeutic food in sub-Saharan Africa: a longitudinal study. *Journal of the International AIDS Society, 14*(1), 2.

Ares, G., Antúnez, L., Bruzzone, F., Vidal, L., Giménez, A., Pineau, B., et al. (2015). Comparison of sensory product profiles generated by trained assessors and consumers using CATA questions: Four case studies with complex and/or similar samples. *Food Quality and Preference, 45*, 75-86.

Ares, G., Barreiro, C., Deliza, R., Giménez, A., & Gambaro, A. (2010). Application of a check all that apply question to the development of chocolate milk desserts. *Journal of Sensory Studies, 25*(s1), 67-86.

Ares, G., Dauber, C., Fernández, E., Giménez, A., & Varela, P. (2014). Penalty analysis based on CATA questions to identify drivers of liking and directions for product reformulation. *Food Quality and Preference, 32*, 65-76.

Ares, G., & Jaeger, S. (2014). Check-all-that-apply (CATA) questions with consumers in practice. Experimental considerations and impact on outcome. *Rapid Sensory Profiling Techniques: Applications in New Product Development and Consumer Research*, 227-245.

Ares, G., & Jaeger, S. (2015). Check-all-that-apply (CATA) questions with consumers in practice: Experimental considerations and impact on outcome. In, *Rapid sensory profiling techniques*: Elsevier.

Ares, G., Tárrega, A., Izquierdo, L., & Jaeger, S. R. (2014). Investigation of the number of consumers necessary to obtain stable sample and descriptor configurations from check-all-that-apply (CATA) questions. *Food Quality and Preference, 31*, 135-141.

Cantarero, L., Espeitx, E., Gil Lacruz, M., & Martín, P. (2013). Human food preferences and cultural identity: The case of Aragón (Spain). *International Journal of Psychology, 48*(5), 881-890.

de Graaf, C., Kramer, F. M., Meiselman, H. L., Lesher, L. L., Baker-Fulco, C., Hirsch, E. S., et al. (2005). Food acceptability in field studies with US army men and women: relationship with food intake and food choice after repeated exposures. *Appetite, 44*(1), 23-31.

Derlagen, C., & Phiri, H. (2019). Analysis of incentives and disincentives for groundnuts in Malawi. *F1000Research, 3*.

Dibari, F., Bahwere, P., Le Gall, I., Guerrero, S., Mwaniki, D., & Seal, A. (2012). A qualitative investigation of adherence to nutritional therapy in malnourished adult AIDS patients in Kenya. *Public health nutrition, 15*(2), 316-323.

Dibari, F., Bahwere, P., Le Gall, I., Guerrero, S., Mwaniki, D., & Seal, A. (2012). A qualitative investigation of adherence to nutritional therapy in malnourished adult AIDS patients in Kenya. *Public Health Nutr, 15*(2), 316-323.

Faintuch, J., Soeters, P. B., & Osmo, H. G. (2006). Nutritional and metabolic abnormalities in pre-AIDS HIV infection. *Nutrition, 22*(6), 683-690.

FAO, I., UNICEF, WFP and WHO. (2018). FAO, IFAD, and WFP. The State of Food insecurity in the World 2018. Building climate resilience for food security and nutrition. . In, *Advances in Nutrition*.

Kebede, M. A., & Haidar, J. (2014). Factors influencing adherence to the food by prescription

program among adult HIV positive patients in Addis Ababa, Ethiopia: a facility-based, cross-sectional study. *Infectious diseases of poverty, 3*(1), 20.

Koethe, J. R., Chi, B. H., Megazzini, K. M., Heimburger, D. C., & Stringer, J. S. (2009). Macronutrient supplementation for malnourished HIV-infected adults: a review of the evidence in resource-adequate and resource-constrained settings. *Clinical Infectious Diseases, 49*(5), 787-798.

Lawless, H. T., & Heymann, H. (2010). *Sensory evaluation of food: principles and practices*: Springer Science & Business Media.

Le, S., & Worch, T. (2014). *Analyzing sensory data with R*: CRC Press.

Meyners, M., & Castura, J. C. (2014). Novel Techniques in Sensory Characterization and Consumer Profiling.

Meyners, M., Castura, J. C., & Carr, B. T. (2013). Existing and new approaches for the analysis of CATA data. *Food Quality and Preference, 30*(2), 309-319.

Ministry of Health, Government of Malawi. (2006). Interim Guidelines for the Management of Acute Malnutrition in Adolescents and Adults.

Ndekha, M. J., van Oosterhout, J. J., Zijlstra, E. E., Manary, M., Saloojee, H., & Manary, M. J. (2009). Supplementary feeding with either ready-to-use fortified spread or corn-soy blend in wasted adults starting antiretroviral therapy in Malawi: randomised, investigator blinded, controlled trial. *Bmj, 338*, b1867.

Olsen, M. F., Tesfaye, M., Kaestel, P., Friis, H., & Holm, L. (2013). Use, perceptions, and acceptability of a ready-to-use supplementary food among adult HIV patients initiating antiretroviral treatment: a qualitative study in Ethiopia. *Patient Prefer Adherence, 7*, 481-488.

World Health Organization (2016). *Consolidated guidelines on the use of antiretroviral drugs for treating and preventing HIV infection: recommendations for a public health approach*: World Health Organization.

Rodas-Moya, S., Kodish, S., Manary, M., Grede, N., & de Pee, S. (2016). Preferences for food and nutritional supplements among adult people living with HIV in Malawi. *Public Health Nutr, 19*(4), 693-702.

Rodas-Moya, S., Pengnonyang, S., Kodish, S., de Pee, S., & Phanuphak, P. (2017). Psychosocial factors influencing preferences for food and nutritional supplements among people living with HIV in Bangkok, Thailand. *Appetite, 108*, 498-505.

Rozin, P., & Vollmecke, T. A. (1986). Food likes and dislikes. *Annu Rev Nutr, 6*, 433-456.

UNAIDS. (2018). UNAIDS DATA 2018. 18, 20, 48.

Weiser, S. D., Young, S. L., Cohen, C. R., Kushel, M. B., Tsai, A. C., Tien, P. C., et al. (2011). Conceptual framework for understanding the bidirectional links between food insecurity and HIV/AIDS–. *The American journal of clinical nutrition, 94*(6), 1729S-1739S.

WHO. (2004). Nutrient requirements for people living with HIV.

Williams, E. (1949). Experimental designs balanced for the estimation of residual effects of treatments. *Australian Journal of Chemistry, 2*(2), 149-168.

Young, S., Wheeler, A. C., McCoy, S. I., & Weiser, S. D. (2014). A review of the role of food insecurity in adherence to care and treatment among adult and pediatric populations living with HIV and AIDS. *AIDS and Behavior, 18*(5), 505-515.

Zandstra, E. H., de Graaf, C., van Trijp, H. C., & van Staveren, W. A. (1999). Laboratory hedonic ratings as predictors of consumption. *Food Quality and Preference, 10*(4-5), 411-418.

ANNEX 1

Nutrient composition of the nutritious drink in comparison to RNI, DRI, RDA and AI reference values for specific nutrients, as well as reference intake of nutrient requirements of a 2500 kcal diet to treat malnutrition.

Energy and Nutrients	**Unit**	**RNI[1]/DRI[2] RDA[3]/AI[4] males 19-65**	**RNI/DRI[a] RDA[b]/AI[c] females 19-50**	**80% of MN needs of a 2500 kcal[5]**	**ND 100 (g)**	**ND 200 (g)**
Energy (kcal)	Kcal	NS[6]	NS	2000	370	740
Protein	g	56[3]	46[3]	41.6	10.0	20.0
Carbohydrates	g	130[3]	130[3]	NS	75.8	151.6
Fat	g	20-35[3]	20-35[3]	NS	3.0	6.0
Retinol (Vit A)	mcg	600	500	3800	700	1400
Thiamin (Vit B1)	mg	1.2	1.1	2.0	1.0	2.0
Riboflavin (Vit B2)	mg	1.3	1.1	3.6	1.8	3.6
Niacin (Vit B3)	mg	16.0	14.0	36.0	18.0	36.0
Pantothenic Acid (Vit B5)	mg	5.0	5.0	6.0	5.0	10.0
Pyridoxine (Vit B6)	mg	1.3[7]	1.3	3.6	2.0	4.0
Biotin (Vit B7)	mcg	30.0	30.0	26.0	25.0	50.0
Folate (Vit B9)	mcg	400.0	400.0	700.0	350.0	700.0
Cobalamin (Vit B12)	mcg	2.4	2.4	5.2	2.6	5.2
Ascorbate (Vit C)	mg	45.0	45.0	200.0	100.0	200.0
Cholecalciferol (Vit D)	mcg	10.0	7.5	22.0	15.0	30.0
DI- tocopherol acetate (Vit E)	mg	10.0	7.5	44.0	22.0	44.0
Phytomenadione (Vit K)	mcg	65.0	55.0	80.0	40.0	80.0
Calcium (Ca)	mg	1000.0	1000.0	1680.0	620.0	1240.0
Copper (Cu)	mg	0.7[2]	0.7[2]	1.8	0.9	1.8
Iodine (I)	mcg	130.0	110.0	400.0	200.0	400.0
Iron (Fe)	mg	27[8]	59[8]	36.0	12.0	24.0
Magnesium (Mg)	mg	260.0	220.0	600.0	100.0	200.0
Manganese (Mn)	mg	2.3[4]	1.8[4]	2.4	1.6	3.2
Phosphorus (P)	mg	580[2]	580[2]	1800.0	450.0	900.0
Potassium (K)	mg	4700[4]	4700[4]	3200.0	400.0	800.0
Selenium (Se)	mcg	34.0	26.0	110.0	55.0	110.0
Zinc (Zn)	mg	14[9]	9.8[9]	40.0	20.0	40.0

[1] The FAO/WHO recommended nutrient intakes (RNIs) (World Health Organization. & Food and Agriculture Organization of the United Nations., 2004) were used for most of the micronutrients. When RNIs were not available, DRIs, RDAs or AIs were used as specified by the superscripts 2, 3 and 4.

[2] The Dietary Reference Intakes (DRIs), Recommended Dietary Allowances (RDAs)[3] are nutrient reference values developed by the Institute of Medicine of The National Academies of the United States of America. They can be used as goals for individual or group intake,

and as a guide for the formulation of oral nutritional supplements or of complete enteral and parenteral feeding solutions. RDAs are set to meet the needs of almost all (97 to 98 percent) individuals in a group of a specific age and gender. Values for this table are specified for males and females 18-50 y. These values were used when the WHO RNIs for the specified nutrients were not available (Institute of Medicine (U.S.). Subcommittee on Interpretation and Uses of Dietary Reference Intakes., Institute of Medicine (U.S.). Subcommittee on Upper Reference Levels of Nutrients., & Institute of Medicine (U.S.). Standing Committee on the Scientific Evaluation of Dietary Reference Intakes., 2000). Updates were obtained from: www.nap.edu

[4] Some nutrients have an Adequate Intake (AI) because the evidence was not sufficient to establish an estimated average requirement (EAR) and thus an RDA for the nutrient in question. Usual intake at or above the AI level has a low probability of inadequacy. AIs are nutrient reference values developed by the Institute of Medicine (IOM) of The National Academies of the United States of America. RNI, RDA or AI references values were used when the WHO RNIs were not available for specific nutrients (Institute of Medicine (U.S.). Subcommittee on Interpretation and Uses of Dietary Reference Intakes. et al., 2000).

[5] Eighty percent of micronutrient needs for a diet used to treat moderate acute malnutrition i.e. 2500 kcal diet. (Golden, 2009).

[6] Not specified

[7] 1.3 from 19-50 y; 1.7 for 50+ years

[8] Values adjusted for a diet of an estimated 5% of bioavailability.

[9] Values adjusted for a diet of low estimated bioavailability.

Chapter 6

A novel nutritious drink led to higher micronutrient intake compared to a ready-to-use therapeutic food and Super Cereal among adults living with HIV in Malawi

Santiago Rodas-Moya
Saskia de Pee
Mark Manary
Lameck Kachali
Cees de Graaf

Under revision by program stakeholders.

ABSTRACT

In food-insecure settings, malnourished people with HIV (PLHIV) need a nutrient supplement to restore their nutritional status. A novel nutritious drink was developed, and its ad libitum intake was compared to that of a ready-to-use therapeutic food (RUTF) and Super Cereal (SC). We tested the hypothesis that ad libitum intake of the nutritious drink leads to a higher micronutrient intake compared to RUTF and SC. Fifty-four PLHIV 18-49 years old, on antiretroviral therapy, with a BMI of ≥ 17 kg/m2 and ≤ 25 kg/m2 participated in the study. Data were collected at the Chilomoni Clinic in Blantyre, Malawi over two months. Each participant attended the clinic on three consecutive days. A standardized breakfast was served every morning. Two hours after breakfast, the participants rated their state of hunger. Next, they received, in random order, mouthful portions of the nutritious drink, RUTF, and SC and rated their liking and wanting of each. Subsequently, one of the nutrient supplements was randomly assigned for ad libitum consumption to satiation. The participants re-rated their state of hunger, liking and wanting of each of the three products two and 20 minutes after ingesting the randomly assigned product to satiation. On day two and day three, the same protocol was followed with a different nutrient supplement provided ad libitum. The intake of the nutritious drink (356 g) was significantly higher ($p<0.05$) compared to RUTF (107 g) and SC-porridge (312 g). The average intake of eight essential micronutrients as a percentage of target quantities was 58 % from the nutritious drink, 33 % from RUTF, and 20 % from SC. The average caloric intake from the nutritious drink, RUTF, and SC was 507, 581, and 339 kcal, respectively. A more substantial weight of food and larger quantities of micronutrients were ingested from the nutritious drink. Nutrient-dense food supplements in liquid form may be more effective than semisolid products in treating undernutrition among adult PLHIV.

INTRODUCTION

In Malawi, approximately one million people are living with HIV (UNAIDS, 2018). Severe food insecurity affects five out of 10 Malawians (FAO, 2018). Food insecurity, the consequent malnutrition, and HIV coexist and may affect the same person/s within a household (Gebremichael, Hadush, Kebede, & Zegeye, 2018). In food-insecure settings, the majority of people living with HIV (PLHIV) have restricted access to nutritious foods, particularly those rich in high-quality protein and micronutrients (Aranka Anema et al., 2009; Gebremichael et al., 2018). Thus, nutrient supplements are often required to help PLHIV meet their nutrient requirements (Saskia De Pee & Richard D Semba, 2010).

Among adult PLHIV in Malawi, ready-to-use therapeutic foods (RUTF) or corn-soy-blends such as Super Cereal (SC) are provided to treat uncomplicated malnutrition. RUTF is a paste made from full-fat milk powder, sugar, peanut butter, vegetable oil, and a premix of vitamins and minerals. It was originally developed for treating malnutrition in children (Schoonees, Lombard, Musekiwa, Nel, & Volmink, 2013). However, it is also used for treating severe and moderate malnutrition among adult PLHIV (Government of Malawi. Ministry of Health, 2006). SC is made of maize and soy flours enriched with vitamins and minerals. It is prepared as porridge by mixing one part of the product with four to six parts of water. According to the instructions from the manufacturer, SC needs to be cooked at the simmering point for about ten minutes to reach the desired thickness. Despite these recommendations, we observed that in Malawi, the product is cooked much longer, for about 1 hour, until the porridge becomes slightly dark.

To treat moderate malnutrition in adults, portions > 200 g/d of RUTF (>1000 kcal/d) are prescribed. For severely malnourished PLHIV up to 500 g/d (>2500 kcal/d) is advised (Saskia De Pee & Richard D Semba, 2010; Government of Malawi. Ministry of Health, 2006). Alternatively, SC may be used for treating moderately malnourished adult PLHIV. In that case, amounts that provide 1500 kcal/d (Government of Malawi. Ministry of Health, 2006) are recommended. This caloric intake can be achieved by preparing 300 g of SC with ~30 ml of oil, and ~25 grams of sugar. However, to prepare 300 g of SC, approximately 1.3 liters of water is needed, resulting in > 1 kg of porridge.

Several barriers to the compliant use of RUTF (F. Dibari, P. Bahwere, et al., 2012; Mesrach Ayalew Kebede & Jemal Haidar, 2014) and SC (Matilsky et al., 2009; Navarro-Colorado, 2007) have been reported. For RUTF, frequently reported obstacles to compliance are its intense sweet taste, the large doses prescribed (≥200 g/d), the long treatment period (~4 months) (F. Dibari, P.

Bahwere, et al., 2012; Mesrach Ayalew Kebede & Jemal Haidar, 2014), and clinical conditions related to HIV such as anorexia, difficulty eating or swallowing, and nausea (F. Dibari, P. Bahwere, et al., 2012). Concerning SC, although it is a familiar and well-accepted product (Matilsky et al., 2009), the intake of large daily doses seem to be challenging for PLHIV who often suffer from anorexia (Faintuch et al., 2006; Mangili et al., 2006). Furthermore, because the product is prepared in large amounts, it is often shared with other family members (S. Rodas-Moya et al., 2016) resulting in a dilution of nutritional therapy. The indicated barriers to the recommended intake of RUTF and SC prompted us to develop an alternative nutrient supplement for PLHIV to achieve greater nutrient intake.

Based on formative research (S. Rodas-Moya et al., 2016), we developed a palatable drink of high nutritional value with sensory properties comparable to Maheu, a maize-based drink of sweet and sour flavor frequently consumed in Malawi. Using a drink as a nutrient supplement for PLHIV may have several advantages. Drinks have a lower viscosity than semisolid products (such as RUTF and SC). Therefore, oral processing is faster and demands less eating effort (de Graaf, 2012; De Wijk et al., 2008; Zijlstra et al., 2009; Zijlstra et al., 2008). Hence, consuming a liquid nutrient supplement may be particularly attractive for PLHIV who often become tired from chewing (S. Rodas-Moya et al., 2016).

Furthermore, it has been demonstrated that the bite-size of liquids is larger than that of solids and that their speed of consumption is also higher (Zijlstra et al., 2009). Larger bite sizes and a faster speed of consumption result in greater weight intake of food per minute, i.e., a higher eating rate (de Graaf, 2012; De Wijk et al., 2008; Zijlstra et al., 2009). Hence, nutrient supplements in liquid form may facilitate the treatment of malnutrition among adult PLHIV because they may be able to consume a larger volume of food and nutrients from a beverage than from a semisolid or solid supplement.

In this study, we aimed to test the hypothesis that a palatable fortified drink could lead to a higher ad libitum intake and higher ingestion of micronutrients compared to RUTF and SC.

METHODS

This study was conducted following the *Guidelines for Biomedical Studies Involving Human Subjects (Helsinki Declaration)* and was approved by the College of Medicine Research Ethics Committee of the University of Malawi P.04/17/2158. All participants gave their written informed consent and received a compensation of U$D 10 (paid in local currency).

Participants

PLHIV on antiretroviral therapy (ART), aged 18-49 years with a body mass index (BMI) ≥ 17 kg/m^2 and < 25 kg/m^2 were included in the study. The participants did not present with other major health challenges. Exclusion criteria included HIV clinical-stage ≥ 3 (based on the classification of clinical staging from the World Health Organization (Kassa et al., 1999)), a BMI ≥ 25, as well as difficulty eating or swallowing. The participants were contacted at home by the Health Surveillance Assistants (HSAs) from Chilomoni clinic. The HSAs are government employees that perform health promotion activities at Chilomoni clinic and in rural communities surrounding Blantyre. When participants attended the clinic on the first day of data collection, their body weight and height were measured, and their BMI was calculated. We also conducted a thorough medical history to ensure that the participants met the inclusion criteria. A total of 54 PLHIV (24 males and 30 females) participated. Their sociodemographic and health characteristics are presented in table 6.1.

Table 6.1. Sociodemographic and health characteristics of participants

Age (in years)	
Mean (SD)	33.5 (± 8.5)
Gender	
Male (n)	24
Female (n)	30
ART regime	
2A[1] (n)	4
5A[2] (n)	50
HIV stage	
Primary infection	1
Stage 1	34
Stage 2	19

BMI categories	
17 - <18.5 kg / m^2	5
≥ 18.5 to 24.99 kg / m^2	49
Smoking status	
Yes	0
No	54
Monthly income (MWK[3])	
0-6000	9
6001-12000	6
>12000	39
Education	
Primary school	17
High school	34
More than high school	3

[1] 2A Zidovudine 300 mg; lamivudine 150 mg; nevirapine 200 mg
[2] 5A Tenofovir disoproxil fumarate 300 mg; lamivudine 300 mg; efavirenz 600 mg
[3] U$D 1 = 740 Malawian Kwacha (MWK)

Nutrient supplements

The nutritious drink

The nutritious drink is a fortified product made of maize and soy flours, full-fat milk powder, sugar, maltodextrin, and a premix of 22 micronutrients added in ~1 Recommended Nutrient Intake (RNI)/100 g. The Nutritious drink was developed in the form of powder that requires reconstitution with drinking water at room temperature. The nutritional composition of the product was designed for supplementing the diet of adults, in particular, adults living with HIV. The nutrient target of the nutritious drink is based on a proposed consumption of ~250 ml, twice a day between meals. One serving of 250 ml can be prepared by adding the 100 g of powder from the sachet to a plastic container and adding water to form a portion of ~250 ml. Two portions (~500 ml or 200g of powder) provide ~740 kcal and ~80 % of the micronutrients required from a 2500 kcal diet for treating malnutrition (Golden, 2009). The nutrient composition of the nutritious drink is presented in table 6.2.

Ready-to-use therapeutic food (RUTF)

RUTF is a homogenous lipid-rich paste with a nutritional profile similar to the World Health Organization's recommended therapeutic milk formula, F-100,

used for treating children with severe wasting (also known as 'severe acute malnutrition'). The primary ingredients of RUTF are peanuts, oil, sugar, full-fat milk powder, vitamins, and minerals (M. J. Manary, 2006). RUTF does not require preparation, and it can be consumed directly from the sachet. The nutrient composition of RUTF is presented in table 6.2.

Super Cereal

Super cereal is a type of corn-soy-blend used in food assistance programs to prevent and address nutritional deficiencies, in particular among older children (5 years and above) and adults. The primary ingredients of SC are corn, soybeans, occasionally sugar (10 g/100 g), vitamins, and minerals. SC is prepared by adding water and cooking it to a boiling point. Some oil can also be added (20 g per 200 g) before or during preparation. It is served as a semisolid porridge. The nutrient composition of SC is presented in table 6.2.

Table 6.2. Nutrient composition of the nutritious drink powder (ND), RUTF and SC powder per 100 g of unprepared product

	Unit	Target[1]	ND[2]	RUTF	SC
Energy	kcal	2500	370	543.5	380
Macronutrients					
Protein	g	52	10	14	14
Carbohydrates[3]	g	NS	75.8	42	64
Fat	g	NS	3	36	6
Micronutrients					
Retinol (Vit A)	mcg	3800.0	700.0	910	800.0
Thiamin (Vit B1)	mg	2.0	1.0	0.6	0.4
Riboflavin (Vit B2)	mg	3.6	1.8	1.8	1.6
Niacin (Vit B3)	mg	36.0	18.0	5.3	10.0
Pantothenic Acid (Vit B5)	mg	6.0	5.0	3.1	2.0
Pyridoxine (Vit B6)	mg	3.6	2.0	0.6	0.8
Biotin (Vit B7)	mcg	26.0	25.0	65.0	8.0
Folate (Vit B9)	mcg	700.0	350.0	210.0	160.0
Cobalamine (Vit B12)	mcg	5.2	2.6	1.8	2.0
Ascorbate (Vit C)	mg	200.0	100.0	53.0	60.0
Cholecalciferiol (Vit D)	mcg	22.0	15.0	16.0	8.0
Dl-α tocopherol (Vit E)	mg	44.0	22.0	20.0	8.0

Phytomenadione (Vit K)	mcg	80.0	40.0	21.0	20.0
Calcium (Ca)	mg	1680.0	620.0	300.0	500.0
Copper (Cu)	mg	1.8	0.9	1.8	0.4
Iodine (I)	mcg	400.0	200.0	100.0	60.0
Iron (Fe)	mg	36.0	12.0	11.5	11.0
Magnesium (Mg)	mg	600.0	100.0	92.0	112.0
Manganese (Mn)	mg	2.4	1.6	0.0	0.4
Phosphorus (P)	mg	1800.0	450.0	300.0	500.0
Potassium (K)	mg	3200.0	400.0	1111.0	800.0
Selenium (Se)	mcg	110.0	55.0	30.0	14.0
Zinc (Zn)	mg	40.0	20.0	14.0	8.0

[1] The target intake of micronutrients is 80% of the requirement for moderate acute malnutrition (MAM) treatment for a 2500 kcal diet. Protein (g) covers 100 % of the requirement from a 2500 kcal diet and assumes a protein digestibility-corrected amino acid score of 1.0 and a high digestibility (Golden, 2009).

[2] Nutritious Drink

[3] From the specified weight of carbohydrate, the percentage of sugar for the ND, RUTF, and SC is 17 %, 28 %, and 10%, respectively.

Preparation of nutrient supplements for ad libitum intake

Isocaloric portions of 1000 kcal of the three products were prepared. We prepared the nutritious drink by adding 430 ml of bottled water at room temperature to 270 g of powder in a plastic container. The content was mixed vigorously until the mixture became homogeneous. The resulting 700 ml of the nutritious drink was served in a 2-liter container, together with a 400 ml plastic cup.

To prepare the SC, we followed the directions that the HSAs from Chilomoni clinic provide to PLHIV when distributing the product. In a pan, 237 g of SC, 25 g of sugar (amounting to 1000 kcal), and 1-liter of water were added. The ingredients were continuously stirred while cooking the mixture with firewood until the resulting porridge became slightly dark, and somewhat firm after 1-hour. The preparation resulted in ~1000 g of porridge. The porridge was served in a big container with a ladle, together with a small bowl and a tablespoon. We served portions of 184 g of RUTF on a cake-size plate together with a teaspoon.

Preparation of nutrient supplements for taste tests

To prepare the mouthful samples of the nutrient supplements for the taste tests, we followed the same procedures mentioned above, but we adjusted the quantity of each product as needed. The samples were prepared 10 minutes

before conducting the tests. We purchased the plates, cups, and spoons used for the tests in the market in Blantyre. Thus, their sizes, shapes, and colors were familiar for the participants.

Setting

The study was undertaken at Chilomoni clinic in a well ventilated and illuminated room (generally used for education sessions and staff meetings) free of odors and noise. Five tables were covered with white table cloths, and two chairs were placed around each table. The distance between tables was approximately 1.5 m Besides the test food and appropriate utensils, a napkin and a bottle of water we provided. In the room, the preparation area was separated from the participants with a folding screen.

Experimental procedure

Fifty-four participants were divided into 11 groups -ten groups of 5 and one of 4. Each participant worked with a research assistant who guided her/him through the process. One group of participants at a time attended the clinic on three consecutive days. The procedures described below were iterative across the three days and across participants. Figure 6.1 summarizes the study design.

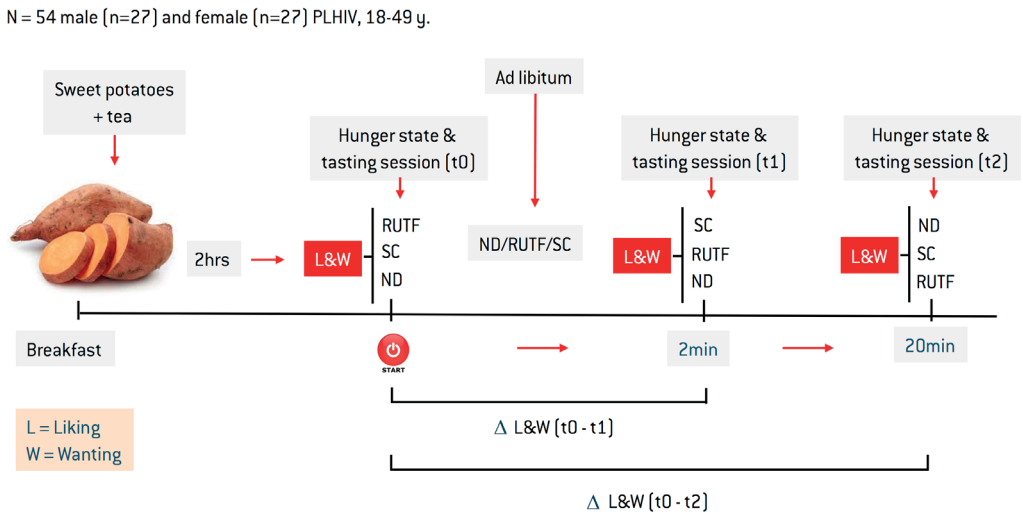

Figure 6.1. Summary of the study design employed for assessing the ad libitum intake of the nutritious drink (ND) compared to RUTF, and SC porridge. The products offered for ad libitum intake were served in isocaloric portions of 1000 kcal. All products were served monadically, following a Williams Latin square design. The procedure outlined above was iterative across participants.

The sessions were conducted every day from 08h:30 to 12h:00. To ensure that all participants had a similar state of hunger before offering them the supplements for ad libitum intake, all participants had a standardized breakfast at 08h:30 at Chilomoni clinic. Breakfast consisted of 200 g of cooked orange-flesh sweet potatoes without the peal and 400 ml of tea sweetened with 35 g of sugar. Participants were invited to consume the food ad libitum. The average consumption of sweet potatoes was 165 g (± 41 g). The average consumption of tea was 295 ml (± 121 ml). The mean caloric intake from tea and sweet potatoes was 232 kcal (± 58 kcal). Eating or drinking anything after this breakfast was prohibited.

Two-hours after the breakfast, we asked the participants to rate their state of hunger on a 7-point horizontal scale with anchors "I am not hungry at all" on the left, and "I am very hungry" on the right. Mouth-full portions of the nutritious drink (20 ml), RUTF (1 teaspoon) and SC porridge (1 teaspoon) were then served monadically to each participant following a Williams Latin square design (Williams, 1949) - a complete randomized block design balanced for carry-over and position effect. After consuming each sample, the participants were asked to rate their hedonic response (liking) and desire (wanting) to consume the products on 7-point horizontal scales with smiley face graphics and anchors "I dislike extremely", "I like extremely", and "I don't want it all", "I really want it" on the right and left sides of the scales, respectively. In between sample tasting, participants took a sip of water to rinse their mouths. After rating each sample for both liking and wanting, each participant was served, for ad libitum consumption, one of the three nutrient supplements randomly. The products were served in isocaloric portions of 1000 kcal. Participants were asked to consume the supplement until they felt comfortably full.

Next, the participants indicated their state of hunger, and rated all three samples two minutes and twenty minutes after ad libitum consumption, using the aforementioned protocol. The ratings at 2 min after satiation were used to assess the change in liking and wanting in comparison to the initial rating before ad libitum consumption. The ratings at 20 min were used to assess the change in liking and wanting as digestion and absorption of nutrients progressed. On day two, each participant was served, for ad libitum consumption, one of the two supplements which they did not receive on day one, and on the third day, the final supplement was served. While the participants were consuming the products ad libitum, we measured the ingestion time with a stopwatch, and we counted the number of sips and bites required to consume the products to satiation. The leftovers were weighed to estimate the intake of each product. The consumption time and weight of food

ingested were used to calculate the eating rate (g/min). We conducted the study over eight weeks from August-October, 2018.

Estimates of micronutrient intake

Using the micronutrient content per 100 grams of the nutritious drink, SC and RUTF, and the amount consumed ad libitum from the products, we estimated the intake of 23 micronutrients for each participant. The average intake of the 23 micronutrients across all participants was then calculated.

Statistical analysis

Data are presented as means and standard deviations. The data analysis was conducted in SPSS® Statistics version 23. Significance was tested at $p < 0.05$, two-tailed. We used univariate analysis of variance to explore significant differences in the amount consumed of the supplements, as well as on the number of sips/bites, ingestion time, and eating rate. The GLM procedure was used with "Products" set as a fixed factor. A similar analysis was conducted to explore significant differences in the ingestion of eight essential micronutrients as well as on the hunger states and the liking and wanting scores of the nutritious drink, RUTF, and SC. The least significant difference (LSD) test was used to identify the differences between products.

RESULTS

Intake of nutrient supplements

Table 6.3 shows that the number of grams ingested from the nutritious drink was significantly higher than that of the RUTF and SC porridge [$F(2, 159) = 69$; $p < 0.0001$]. The caloric intake from the RUTF and the nutritious drink was substantially higher than that of SC porridge ($F(2, 159) = 15{,}8$; $p < 0.0001$). The mean ingestion time of the nutritious drink was significantly lower compared to RUTF and SC [$F(2, 159) = 3.7$; $p < 0.05$]. The average eating rate for the nutritious drink was much higher than both RUTF and SC [$F(2, 159) = 72.8$; $p < 0.0001$].

Table 6.3. Average intake (in grams and calories), number of sips/bites, consumption time and eating rate of the nutritious drink (ND), RUTF, and SC.

Product		Intake (g)	Intake (kcal)	Sips / bites	Ingestion time (seconds)	Eating rate (g/min)
ND	Mean	356 [a]	508 [a]	14 [a]	163 [a]	163 [a]
	(SD)	(± 144)	(± 205)	(10)	(± 101)	(± 87)
RUTF	Mean	107 [b]	581 [a]	13 [a]	212 [b]	35 [b]
	(SD)	(± 57)	(± 308)	(± 8)	(± 137)	(± 17)
SC	Mean	312 [c]	339 [b]	22 [b]	215 [b]	94 [c]
	(SD)	(± 132)	(± 144)	(± 11)	(± 97)	(± 37)

* Products in a column with the same superscript do not differ significantly according to Fisher´s LSD test.

Average ingestion of eight essential micronutrients from the nutritious drink, RUTF, and SC

Figure 6.2 shows the average intake of vitamins A, B 12, C, E, calcium, iron, selenium, and zinc expressed as percentages of the targeted quantity, which was chosen to be 80 % of the recommended micronutrients from a 2500 kcal diet designed to treat malnutrition (Golden, 2009). Except for vitamin A, the ingestion of the assessed micronutrients was substantially higher from the nutritious drink [$F(2, 1272) = 59.5$, $p < 0.0001$]. The average coverage of micronutrients was 58 % from the nutritious drink, 33 % from the RUTF, and 20 % from the SC (expressed a percentage of the targeted quantity).

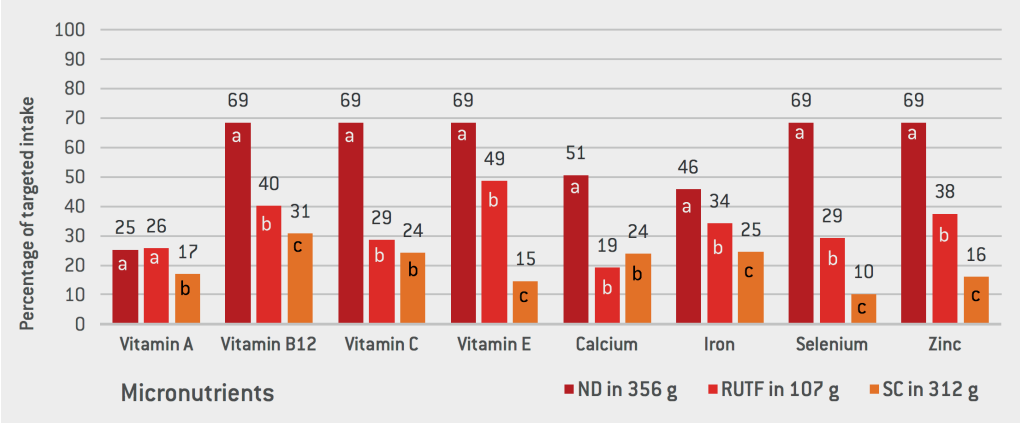

Figure 6.2. Estimated intake of Vitamin A, Vitamin B12 Vitamin C, Vitamin E, calcium, iron, selenium, and zinc from the average consumption (ad libitum) of the ND, RUTF, and SC porridge eaten to satiation. Data are presented as percentages of targeted intake -80 % of the micronutrients required from a 2500 kcal diet designed to treat malnutrition. Percentages are presented on the Y-axis and on top of each bar. Products with the same letter do not differ significantly according to Fisher´s LSD test.

Table 6.4 displays a complementary comparison of the estimated nutrient intake from the ingestion (ad libitum) of the nutritious drink, RUTF, and SC porridge. Twenty-three micronutrients are presented. The percentages of intake are also shown using the targeted ingestion amount as a reference.

Table 6.4. Estimated ingestion (and percentages of target) of micronutrients from the nutritious drink, RUTF, and SC porridge from portions consumed ad libitum.[1]

Macronutrients	Units	Target[2]	ND	% of target (ND)	RUTF	% of targe (RUTF)	SC	% of target (SC)
Retinol (Vit A)	mcg	3800	959.0	25	976.0	26	641.6	17
Thiamin (Vit B1)	mg	2	1.4	69	0.6	32	0.4	18
Riboflavin (Vit B2)	mg	3.6	2.5	69	1.9	54	1.4	40
Niacin (Vit B3)	mg	36	24.7	69	5.7	16	9.0	25
Pantothenic Acid (Vit B5)	mg	6	6.9	114	3.3	55	1.8	30
Pyridoxine (Vit B6)	mg	3.6	2.7	76	0.6	18	0.7	20
Biotin (Vit B7)	mcg	26	34.3	132	69.8	268	7.2	28
Folate (Vit B9)	mcg	700	480.6	69	224.5	32	143.4	20
Cobalamin (Vit B12)	mcg	5.2	3.6	69	2.1	40	1.6	31
Ascorbate (Vit C)	mg	200	137.0	69	56.9	28	48.1	24
Cholecalciferol (Vit D)	mcg	22	20.6	94	17.4	79	7.2	33
Dl- tocopherol (Vit E)	mg	44	30.1	69	21.4	49	6.4	15
Phytomenadione (Vit K)	mcg	80	54.9	69	22.4	28	17.9	22
Calcium (Ca)	mg	1680	849.4	51	320.7	19	401.0	24
Copper (Cu)	mg	1.8	1.2	69	1.9	105	0.4	20
Iodine (I)	mcg	400	274.6	69	107.0	27	53.8	13
Iron (Fe)	mg	36	16.4	46	12.3	34	8.8	25
Magnesium (Mg)	mg	600	137.3	23	98.4	16	100.4	17
Manganese (Mn)	mg	2.4	2.2	92	0.0	0	0.4	15
Phosphorus (P)	mg	1800	617.9	34	321.0	18	448.0	25
Potassium (K)	mg	3200	549.3	17	1188.6	37	717.6	22
Selenium (Se)	mcg	110	75.4	69	32.1	29	11.2	10
Zinc (Zn)	mg	40	27.4	69	15.0	37	6.4	16

[1] Average consumption of the nutritious drink (356 g), RUTF (107 g) and SC (312g)

[2] The target intake of micronutrients corresponds to 80% of the requirement for MAM treatment from a 2500 kcal diet (Golden, 2009).

Satiety parameters

Table 6.5 shows the satiety parameters (hunger state, liking, and wanting) for the three nutrient supplements before ad libitum consumption of the products, and two and 20 minutes after reaching satiation. Despite the substantial differences in the amount consumed of the nutritious drink, RUTF and SC, the hunger state ratings were comparable, and the liking and wanting scores between the products were similar.

Table 6.5. Scores of hunger state, liking and wanting for the three nutrient supplements measured with 7-point scales before ad libitum consumption of the products, and 2 and 20 minutes after reaching satiation.

Parameters		ND	RUTF	SC	p value
Hunger state	Before ad lib	4.5 ± 1.6	4.5 ± 1.4	4.6 ± 1.6	> 0.05
	After 2 mins	2.6 ± 1.6	2.4 ± 1.5	2.2 ± 1.3	> 0.05
	After 20 mins	2.8 ± 1.6	3.2 ± 1.8	2.5 ± 1.5	> 0.05
Liking	Before ad lib	5.7 ± 1.1	5.6 ± 1.2	5.5 ± 1.1	> 0.05
	After 2 mins	5.2 ± 1.1	5.3 ± 1.2	5.0 ± 1.1	> 0.05
	After 20 mins	5.4 ± 1.2	5.5 ± 1.1	5.3 ± 1.1	> 0.05
Wanting	Before ad lib	4.8 ± 2.1	5.0 ± 1.9	4.6 ± 1.8	> 0.05
	After 2 mins	3.7 ± 2.1	3.6 ± 2.1	3.3 ± 1.8	> 0.05
	After 20 mins	3.9 ± 2.2	4.0 ± 2.1	3.3 ± 1.9	> 0.05

DISCUSSION

To our knowledge, this is the first study that compares the ad libitum intake of a novel liquid nutrient supplement with RUTF and SC porridge among PLHIV. RUTF and SC are a type of lipid-based nutrient supplement and fortified blended food, respectively. These categories of products are used for treating undernutrition among PLHIV (and other population groups) in Malawi ((MOH). 2017), as well as in other low- and middle-income countries by various agencies from the United Nations system to NGOs (Saskia De Pee & Richard D Semba, 2010). Therefore, the implications of our results are highly relevant in the context of international nutrition.

The present work demonstrates substantial differences in the ingestion of micronutrients between the nutritious drink, RUTF, and SC porridge. The differences can be explained by two main factors. First, because the nutritious drink was developed for treating malnutrition among adults, mainly adult PLHIV, the product was fortified at a higher concentration for most of the micronutrients; at about 1 RNI/100 g (Table 6.2). Second, the average ad libitum intake of the nutritious drink (356 g) was substantially higher than the intake of RUTF (107 g) and SC porridge (312 g). The higher average intake of the nutritious drink also contributes to the higher ingestion of micronutrients.

In line with other studies, our results suggest that texture (viscosity) plays a crucial role in the amount of food that people can ingest. It has been

demonstrated that a lower viscosity of beverages leads to the ingestion of more grams per minute; resulting in a higher eating rate (g/min) compared to semisolid and solid foods (De Wijk et al., 2008; Zijlstra et al., 2008). On average, PLHIV consumed 163 g/min of the nutritious drink compared to 35 g/min of RUTF and 94 g/min of SC porridge. The consumption of a larger volume of food from liquids has also been reported from a study conducted by Heber and colleagues (Haber, Heaton, Murphy, & Burroughs, 1977). In that study, the investigators compared the ingestion of cored apples (482g), pureed apples (482g) and apple juice (469g). The participants consumed the apple juice ~11 times faster (in 1.5 min) than the cored apples (17.2 min) and ~ 4 times faster than the pureed apples (5.9 min) (Haber et al., 1977). That study also showed that it was the higher eating rate of liquids that influenced the volume of ingestion.

The consumption of more substantial volumes from beverages may also be explained by a shorter oral processing time and larger bite-size (de Graaf, 2012; Zijlstra et al., 2009). In a study undertaken by Zijlstra and colleagues (Zijlstra et al., 2009), the investigators demonstrated that larger bite-sizes (15 g vs 5 g) consumed in a shorter time (3 vs 9 seconds) lead to a significantly higher intake of food. In another study, de Wijk and colleagues (De Wijk et al., 2008) compared the intake volume of chocolate milk and chocolate custard (matched for energy density). They found that the participants consumed 47 % more from the chocolate milk than from the custard while reaching a similar level of satiation. Similar findings displaying that liquid foods lead to larger intake volumes compared to semisolid and solid food have been shown by various investigators (de Graaf, 2012; De Wijk et al., 2008; Hogenkamp, Stafleu, Mars, Brunstrom, & de Graaf, 2011; Zijlstra et al., 2008).

Because liquids are ingested faster than solids and have a short oral transit time, they may not receive adequate exposure to the taste buds and the sense of taste may go under-detected compared to foods that require chewing (de Graaf, 2011, 2012). The under-detection of taste molecules from liquids seems to explain their weaker effect on the satiety response, which contributes to the ingestion of larger volumes before satiation is reached (de Graaf, 2011, 2012; De Wijk et al., 2008; Zijlstra et al., 2008). These unique attributes of liquids, that semisolids like RUTF and SC do not possess, are attractive for treating undernutrition, particularly among people with decreased appetite due to health challenges such as HIV infection.

The differences in caloric intake between the nutritious drink, RUTF, and SC, can be partly explained by the different caloric densities of RUTF (5.4 kcal/g), the nutritious drink powder (3.7 kcal/g) and SC powder (3.8 kcal/g). When the

nutritious drink and SC (237 g of SC with 25 g of sugar) were prepared with the recommended amount of water, their caloric densities dropped to ~1.4 kcal/g and ~1.1 kcal/g, respectively. However, we observed that the higher intake volume of the nutritious drink and its slightly higher caloric density compared to SC porridge led to a significantly higher caloric intake. In fact, the caloric intake from the average ad libitum consumption of the nutritious drink was almost as high as that of RUTF, which was much more energy dense. This finding clearly shows that beverages can lead to a higher caloric intake compared to semisolid products of comparable caloric densities.

Hence, it should be noted that the nutritious drink is intended specifically for treating undernutrition or for populations with energy requirements higher than those of the general population. The nutritious drink is not recommended for correcting micronutrient deficiencies in overweight or obese people. Several studies have demonstrated that due to the high eating rate of beverages with relatively high caloric content, their consumption can contribute to overweight and obesity (de Graaf, 2011; Della Torre, Keller, Depeyre, & Kruseman, 2016; Haddad et al., 2018; N. Olsen & Heitmann, 2009; WHO, 2015; Stratil et al., 2019; Viskaal-van Dongen, Kok, & de Graaf, 2011).

With regard to the measurement of satiety parameters (hunger state, liking and wanting), in accordance with Zijlstra and colleagues (Zijlstra et al., 2008), we observed that despite the differences in intake volume between the products, no significant differences emerged in the hunger state of participants, neither in their liking and wanting ratings for the nutritious drink, RUTF, or SC porridge after ad libitum consumption. Wansink and colleagues (Wansink, Painter, & North, 2005) also found that satiation parameters were not affected by the number of grams of food consumed.

In this study, we controlled for a number of confounders. First, we standardized the state of hunger of participants by offering them breakfast and ensuring a fasting period of 2-hours before the ad libitum intake of the nutrient supplements. Second, the palatability (liking) of the products was comparable, which indicates that there were no differences in liking that could have influenced the intake of the products. Third, the desire to consume the products (wanting) was also comparable, indicating similar behavioral intentions to consume the three nutrient supplements. Fourth, to control for possible effects of spoon/plate/cup sizes on intake, we used tableware and cutlery commonly used in Malawi. Yet, the nutrient supplements differed in macronutrient composition and thus in energy density. These differences could have affected the satiation response of the participants toward the products (Blundell et al., 2010). Nevertheless, our results, in concurrence with results from various studies (de Graaf, 2012;

De Wijk et al., 2008; Hogenkamp et al., 2011; Zijlstra et al., 2009; Zijlstra et al., 2008), suggest that viscosity is a primary factor influencing the volume of intake and hence the quantity of nutrients consumed from food products.

CONCLUSIONS

The results from this study demonstrate that the micronutrient composition and weight intake of the nutritious drink resulted in the ingestion of a larger quantity of micronutrients compared to RUTF and SC. The use of a beverage in the treatment of undernutrition among adult PLHIV may have a better impact on their nutritional status than RUTF and SC. The high caloric intake of the nutritious drink may also facilitate weight gain; a priority when treating undernutrition among PLHIV who have rapidly lost weight. However, for the same reasons, this product should not be used for treating micronutrient deficiencies among overweight and obese people. Future research should focus on testing the consumption of the nutritious drink, RUTF and SC under real living conditions and for a more extended period, e.g., 14 days.

ACKNOWLEDGMENTS

The authors would like to thank The St. Louis Nutrition Project team for supporting them with logistics and key contacts for setting up this study in Malawi. The authors are also thankful to Dr. Minyanga Nkhoma from the College of Medicine of the University of Malawi for facilitating the recruitment of a great team of field researchers. The authors are also grateful to the World Food Programme Country Office in Malawi for the logistical support related to the import and storage of the nutritious drink samples, and for providing SC and RUTF for conducting this research. We also thank DSM for developing the nutritious drink Samples.

References

(MOH)., M. o. H. (2017). National Guidelines on Nutrition Care, Support, and Treatment (NCST) for Adolescent and Adults. (Second edition ed., pp. 27). Lilongwe, Malawi: MOH.

Anema, A., Vogenthaler, N., Frongillo, E. A., Kadiyala, S., & Weiser, S. D. (2009). Food insecurity and HIV/AIDS: current knowledge, gaps, and research priorities. *Current HIV/AIDS Reports, 6*(4), 224-231.

Blundell, J., de Graaf, C., Hulshof, T., Jebb, S., Livingstone, B., Lluch, A., . . . Westerterp, M. (2010). Appetite control: methodological aspects of the evaluation of foods. *Obes Rev, 11*(3), 251-270. doi:10.1111/j.1467-789X.2010.00714.x

de Graaf, C. (2011). Why liquid energy results in overconsumption. *Proceedings of the Nutrition Society, 70*(2), 162-170.

de Graaf, C. (2012). Texture and satiation: the role of oro-sensory exposure time. *Physiology & behavior, 107*(4), 496-501.

De Pee, S., & Semba, R. D. (2010). Role of nutrition in HIV infection: review of evidence for more effective programming in resource-limited settings. *Food and nutrition bulletin, 31*(4 suppl4), S313-S344.

De Wijk, R., Zijlstra, N., Mars, M., De Graaf, C., & Prinz, J. (2008). The effects of food viscosity on bite size, bite effort and food intake. *Physiology & behavior, 95*(3), 527-532.

Della Torre, S. B., Keller, A., Depeyre, J. L., & Kruseman, M. (2016). Sugar-sweetened beverages and obesity risk in children and adolescents: a systematic analysis on how methodological quality may influence conclusions. *Journal of the Academy of Nutrition and Dietetics, 116*(4), 638-659.

Dibari, F., Bahwere, P., Le Gall, I., Guerrero, S., Mwaniki, D., & Seal, A. (2012). A qualitative investigation of adherence to nutritional therapy in malnourished adult AIDS patients in Kenya. *Public Health Nutr, 15*(2), 316-323. doi:10.1017/S1368980010003435

Faintuch, J., Soeters, P. B., & Osmo, H. G. (2006). Nutritional and metabolic abnormalities in pre-AIDS HIV infection. *Nutrition, 22*(6), 683-690.

FAO, I., UNICEF, WFP and WHO. (2018). *FAO, IFAD, and WFP. The State of Food insecurity in the World 2018. Building climate resilience for food security and nutrition.* . Retrieved from http://www.fao.org/3/I9553EN/i9553en.pdf

Gebremichael, D. Y., Hadush, K. T., Kebede, E. M., & Zegeye, R. T. (2018). Food Insecurity, Nutritional Status, and Factors Associated with Malnutrition among People Living with HIV/AIDS Attending Antiretroviral Therapy at Public Health Facilities in West Shewa Zone, Central Ethiopia. *BioMed research international, 2018*.

Golden, M. H. (2009). Proposed recommended nutrient densities for moderately malnourished children. *Food Nutr Bull, 30*(3 Suppl), S267-342. doi:10.1177/15648265090303S302

Haber, G., Heaton, K., Murphy, D., & Burroughs, L. (1977). Depletion and disruption of dietary fibre: effects on satiety, plasma-glucose, and serum-insulin. *The Lancet, 310*(8040), 679-682.

Haddad, L. J., Hawkes, C., Achadi, E., Ahuja, A., Ag Bendech, M., Bhatia, K., . . . Eriksen, K. (2018). *Global Nutrition Report 2018: Actions and accountability to advance nutrition and sustainable development*: Intl Food Policy Res Inst.

Hogenkamp, P. S., Stafleu, A., Mars, M., Brunstrom, J. M., & de Graaf, C. (2011). Texture, not flavor, determines expected satiation of dairy products. *Appetite, 57*(3), 635-641.

Kassa, E., de Wit, T. F. R., Hailu, E., Girma, M., Messele, T., Mariam, H. G., . . . Coutinho, R. A. (1999). Evaluation of the World Health Organization staging system for HIV infection and disease in Ethiopia: association between clinical stages and laboratory markers. *Aids, 13*(3), 381-389.

Kebede, M. A., & Haidar, J. (2014). Factors influencing adherence to the food by prescription program among adult HIV positive patients in Addis Ababa, Ethiopia: a facility-based, cross-sectional study. *Infectious diseases of poverty, 3*(1), 20.

Manary, M. J. (2006). Local production and provision of ready-to-use therapeutic food (RUTF) spread for the treatment of severe childhood malnutrition. *Food and nutrition bulletin, 27*(3_suppl3), S83-S89.

Mangili, A., Murman, D., Zampini, A., Wanke, C., & Mayer, K. H. (2006). Nutrition and HIV infection: review of weight loss and wasting in the era of highly active antiretroviral therapy from the nutrition for healthy living cohort. *Clinical Infectious Diseases, 42*(6), 836-842.

Matilsky, D. K., Maleta, K., Castleman, T., & Manary, M. J. (2009). Supplementary feeding with fortified spreads results in higher recovery rates than with a corn/soy blend in moderately wasted children. *The Journal of nutrition, 139*(4), 773-778.

Ministry of Health, Government of Malawi. (2006). Interim Guidelines for the Management of Acute Malnutrition in Adolescents and Adults.

Navarro-Colorado, C. (2007). A retrospective study of emergency supplementary feeding programmes. *Save the Children/ENN Available at: http://www.ennonline. net/pool/files/research/Retrospective_Study_of_Emergency_Supplementary_Feeding_Programmes_June, 202007*.

Olsen, N., & Heitmann, B. (2009). Intake of calorically sweetened beverages and obesity. *Obesity reviews, 10*(1), 68-75.

World Health Organization (2015). Sugars intake for adults and children. *WHO: Geneva, Switzerland*, 49.

Rodas-Moya, S., Kodish, S., Manary, M., Grede, N., & de Pee, S. (2016). Preferences for food and nutritional supplements among adult people living with HIV in Malawi. *Public Health Nutr, 19*(4), 693-702. doi:10.1017/S1368980015001822

Schoonees, A., Lombard, M., Musekiwa, A., Nel, E., & Volmink, J. (2013). Ready to use therapeutic food for home based treatment of severe acute malnutrition in children from six months to five years of age. *The Cochrane Library*.

Stratil, J., Burns, J., Busert, L., Pfadenhauer, L., Polus, S., Holzapfel, C., . . . Rehfuess, E. (2019). Environmental interventions to reduce the consumption of sugar-sweetened beverages and their effects on health. *The Cochrane Database of Systematic Reviews, 6*(6), CD012292-CD012292.

UNAIDS. (2018). UNAIDS DATA 2018. 18, 20, 48.

Viskaal-van Dongen, M., Kok, F. J., & de Graaf, C. (2011). Eating rate of commonly consumed foods promotes food and energy intake. *Appetite, 56*(1), 25-31.

Wansink, B., Painter, J. E., & North, J. (2005). Bottomless bowls: why visual cues of portion size may influence intake. *Obesity research, 13*(1), 93-100.

Williams, E. (1949). Experimental designs balanced for the estimation of residual effects of treatments. *Australian Journal of Chemistry, 2*(2), 149-168.

Zijlstra, N., de Wijk, R., Mars, M., Stafleu, A., & de Graaf, C. (2009). Effect of bite size and oral processing time of a semisolid food on satiation. *The American journal of clinical nutrition, 90*(2), 269-275.

Zijlstra, N., Mars, M., de Wijk, R. A., Westerterp-Plantenga, M. S., & de Graaf, C. (2008). The effect of viscosity on ad libitum food intake. *International journal of obesity, 32*(4), 676.

World Health Organization., & Food and Agriculture Organization of the United Nations. (2004). *Vitamin and mineral requirements in human nutrition (2nd ed.). Geneva* Rome: World Health Organization ;FAO.

Young, S., Wheeler, A. C., McCoy, S. I., & Weiser, S. D. (2014). A review of the role of food

insecurity in adherence to care and treatment among adult and pediatric populations living with HIV and AIDS. *AIDS and Behavior, 18*(5), 505-515.
Zandstra, E. H., de Graaf, C., & Van Trijp, H. C. (2000). Effects of variety and repeated in-home consumption on product acceptance. *Appetite, 35*(2), 113-119.
Zandstra, E. H., de Graaf, C., van Trijp, H. C., & van Staveren, W. A. (1999). Laboratory hedonic ratings as predictors of consumption. *Food Quality and Preference, 10*(4-5), 411-418.
Zijlstra, N., de Wijk, R., Mars, M., Stafleu, A., & de Graaf, C. (2009). Effect of bite size and oral processing time of a semisolid food on satiation. *The American journal of clinical nutrition, 90*(2), 269-275.
Zijlstra, N., Mars, M., de Wijk, R. A., Westerterp-Plantenga, M. S., & de Graaf, C. (2008). The effect of viscosity on ad libitum food intake. *International journal of obesity, 32*(4), 676.
Zucco, G. M., & Ingegneri, G. (2004). Olfactory deficits in HIV-infected patients with and without AIDS dementia complex. *Physiology & behavior, 80*(5), 669-674.

Chapter 7

General discussion

This research project aimed to develop a culturally appropriate nutrient supplement with sensory attributes adapted primarily to the preferences of PLHIV. Most of our work was conducted in Malawi. We used qualitative research to identify the cultural and psychosocial factors influencing PLHIV's preferences for food and nutrient supplements. Sensory science techniques were used to study the acceptability of eight samples of a nutritious drink among adults living with and without HIV. We also investigated their perceptions towards the samples, and the drivers of liking and disliking for them. Our last study tested the hypothesis that ad libitum intake of the nutritious drink could lead to the ingestion of larger quantities of micronutrients compared to RUTF and SC. The primary outcomes and findings of our studies are presented in table 7.1.

Table 7.1. Summary of outcomes and findings of the qualitative and sensory studies undertaken to develop the nutritious drink

Outcomes	Findings	Chapters
Factors influencing preferences for nutrient supplements among PLHIV	• Local food culture has a big impact on the choice of nutrient supplements among PLHIV.	2, 3
	• Health challenges associated with HIV influenced preferences towards a soft and easy to swallow texture, softer flavors, and scents.	2,3
	• The self-perceptible positive impact of nutrient supplements on PLHIV's health was a strong determinant for the consumption of nutrient supplements.	2,3
	• Convenience, familiarity, variety, and social aspirations were recurrent motivating factors for the consumption of nutrient supplements.	2,3
	• Thick beverages were the best option for nutrient supplements for the majority of PLHIV in Malawi and Thailand.	2,3
Development of the nutritious drink	• Based on the findings of the formative research, DSM in collaboration with WFP developed eight prototypes of a maze-based drink with sensory characteristics comparable to Maheu, a frequently consumed drink in Malawi.	1
Olfactory and gustatory function of adults and adults living with HIV	• There were significant differences in the olfactory function of healthy adults and PLHIV, suggesting that PLHIV tend to develop hyposmia.	4
	• No significant differences in the gustatory function of PLHIV and healthy adults were found. The gustatory function of healthy adults and PLHIV was normal.	
Sensory acceptability and characterization of the Nutritious drink samples	• There were significant differences in the acceptability of the samples, but no differences in preferences between PLHIV and adults without health challenges.	5

	• Correspondence analysis showed that the samples with the highest acceptability were characterized as sweet and sour, fruity, thick, with a soft texture, and milky flavor.	5
	• Penalty analysis elicited clear recommendations for optimization, i.e., reduce sweetness and sourness, reduce or eliminate beer flavor while keeping a perception of fermentation, increase milky flavor and develop products with banana flavor and strawberry flavor.	5
Ad libitum intake of the nutritious drink, RUTF, and SC	• The ad libitum intake of the nutritious drink (356 g) was significantly higher compared to RUTF (107 g) and SC porridge (312 g)	6
	• The average intake of eight essential micronutrients compared to the targeted daily intake was 58 % from the nutritious drink, 33 % from RUTF and 20 % from SC.	6
	• The average caloric intake from the nutritious drink, RUTF and SC was 507 kcal, 581 kcal, and 339 kcal, respectively.	6
	• The micronutrient composition and weight intake of the nutritious drink led to the ingestion of a larger quantity of micronutrients compared to RUTF and SC.	5

In this chapter, we discuss the main findings, their implications, and recommendations for future research.

Summary of the main findings

The findings from the formative research indicate that food culture is a primary social determinant of nutritional supplements choice among PLHIV. Nutrient supplements were perceived as food. Food culture determines the types of foods that people consume throughout their life course in periods of health and disease. Hence, the appropriateness of food vehicles for nutritional supplementation are largely determined by food culture, which also has a socio-economic specificity (chapters, 2,3). Another factor that emerged as a strong determinant of preference for nutrient supplements—and food was the health challenges that PLHIV experienced. The majority of PLHIV indicated that their preferences towards foods and beverages did not change substantially after becoming HIV positive. However, health challenges such as mouth sores, diarrhea, nausea, and vomiting, as well as chronic weakness led to the selection of foods with soft and easy to swallow textures, and softer flavors and scents. The preference toward these sensory properties emerged as a commonality among PLHIV from Malawi and Thailand.

The self-perceptible impact that food may have on PLHIV's health status was also a strong individual motivator for food and beverage choice. The majority of PLHIV indicated that they reduced the consumption or stopped consuming foods perceived as unhealthy. Examples of unhealthy foods mentioned by PLHIV were those high in fat and sugar or foods that they

considered having a high risk of bacterial contamination, e.g., fermented foods in Thailand. The majority of participants indicated that they try to consume more healthy foods such as citrus fruits, or vegetables and when possible, protein-rich foods. These findings suggest that a nutrient supplement containing ingredients perceived to be healthy may be better accepted for a frequent consumption, while supplements containing ingredients considered unhealthy, such as sugar and oil from RUTF, may not be consumed in required amounts and with the expected frequency.

Other relevant drivers for the consumption of food and nutrient supplements were familiarity, convenience, variety, and social aspirations. Nutrient supplements described as convenient were easy to prepare and carry. The products should be familiar to facilitate their consumption at home or in public places without calling the attention of others, and they should contribute to diet variety. The aspirational social factors linked to the consumption of foods were also strong motivators—or inhibitors—for their consumption. In Malawi, beverages containing milk were described as expensive and were characterized as food consumed by rich people. This was a strong aspirational motivator for the consumption of milk or beverages containing milk. In Thailand, although instant noodles were described as convenient and palatable, they were characterized as "food for the low in cash." This perception was a strong inhibitor of consumption. These findings suggest that convenience, familiarity, variety, and aspirational motivators are intertwined and are key factors that should be considered for the development of nutrient supplements.

Based on the findings of our formative research, DSM in collaboration with the World Food Programme (WFP) developed eight samples of a nutritious powdered drink. Palatability, familiarity, variety, convenience, and aspirational factors were considered for the development of the product. Therefore, we used Maheu, the typical maize drink frequently consumed in Malawi, as a benchmark. The prototypes were easy to prepare by adding the nutritious drink powder in a container with the recommended amount of drinking water and shaking it until the powder was dissolved. The samples had different intensities of sweetness and sourness, two different thicknesses and two different flavors. They also contained milk powder, which gave the samples a milky flavor that could satisfy the consumers' aspirational social factor. We tested the acceptability of the samples and developed their sensory characterization with inputs from PLHIV and healthy adults. We identified the drivers of liking and disliking of the samples and compared the intake (ad libitum) of the nutritious drink sample with the highest acceptability with that of RUTF and SC porridge.

The sensory acceptability testing revealed significant differences between the eight samples of the nutritious drink. However, no differences in preferences between PLHIV and healthy adults emerged. On a 7-point hedonic scale, the average liking scores of the samples ranged from 3.6 to 5.9; and 3.7 to 6.0 among PLHIV and healthy adults, respectively. All the samples were rated similarly by both groups. Correspondence analysis showed that the samples with the highest liking scores were characterized as sweet and sour, fruity, thick, with a soft texture, and milky flavor. The findings from penalty analysis indicated that optimizing the sensory properties of the three samples of the nutritious drink with the highest acceptability ratings could lead to a significant increase in the reward value for the product among PLHIV and healthy adults. Hence, the same set of products could be used for nutrient supplementation programs for adults with and without HIV.

When comparing the ad libitum intake of the nutritious drink (356 g) with that of RUTF (107 g) and SC porridge (312 g), we found significant differences. The liquid texture of the nutritious drink led to a larger volume intake compared to RUTF and SC. In addition to texture, the higher micronutrient content of the nutritious drink also contributed to the larger ingestion of micronutrients. The average intake of eight essential micronutrients compared to the targeted daily intake (~80% of the micronutrients required from a 2500 kcal diet for treating undernutrition (22)) was 58 % from the nutritious drink, 33 % from RUTF and 20 % from SC porridge. The caloric intake of RUTF (581 kcal) and the nutritious drink (508 kcal) was comparable but significantly higher than the caloric intake of SC (339 kcal).

The findings of our studies indicate that a palatable nutrient supplement of convenient use, familiar to the food culture, and that satisfies consumers' psychosocial expectation has a high potential of acceptability for frequent consumption. If the sensory properties of the product are tailored to the preferences of specific population groups, the acceptability and reward value for the product can increase significantly. A high reward value for a nutrient supplement that meets consumers' expectations can contribute to its adherent use and therefore, to improve the efficacy of the nutritional treatment.

Methodological considerations

In this section, we discuss the selection of qualitative and sensory methods for data collection, the criteria for recruiting participants, and considerations for choosing the nutrient supplements. These considerations are relevant for a correct interpretation of the results.

Qualitative studies

The design of the qualitative studies was based on Grounded Theory, an inductive, comparative, emergent, and open-ended methodology (Charmaz, 2014). The Grounded Theory was particularly useful for investigating, understanding, and describing the psychosocial realities constructed by PLHIV when choosing their food and nutrient supplements (chapters 2, 3). We used in-depth interviews (IDIs) as a method for data collection. With the IDI, we investigated PLHIV's experiences, perceptions, and feelings when consuming food and drinks, as well as their preferences for food and nutrient supplements. We also explored PLHIV's knowledge and opinions towards different foods, beverages, and nutrient supplements, as well as barriers and facilitating factors for their regular consumption.

Selection of Participants for qualitative studies

We used a purposeful sampling strategy (Coyne, 1997; Patton, 2002a) to recruit PLHIV, deviant cases (see below) and key informants that were knowledgeable about the factors that influenced preferences for food and nutrient supplements among PLHIV. For PLHIV purposeful sampling criteria included male or female living with HIV, aged 18-49 years, with BMI <18.5 kg/m2 and ≥ 18.5 ≤ 25 kg/m2. The participants did not have major health challenges that impaired them to ingest food or nutrient supplements. All the participants belonged to low-income settings. Deviant cases were participants with different socioeconomic or demographic characteristics. They were included to investigate whether the main patterns of the findings emerging from the majority of participants were the same or different (John W Creswell, 2013; Matthew B Miles, Huberman, & Saldana, 2013; Patton, 2002a). We also included Health Surveillance Assistants (HSAs) in Malawi and Peer Counselors (PCs) in Thailand. HSAs and PCs were part of the health care personnel of the clinics where we conducted the studies. The findings from HSAs and PC and the deviant cases were employed to triangulate data sources (Charmaz & Belgrave, 2002; Patton, 1999). This sampling strategy contributed to strengthen the validity of the qualitative investigations and to add confidence to our results and conclusions (Charmaz, 2014; John W Creswell, 2013; Patton, 1999; Quinn, 2002).

Sample sizes for qualitative studies

The sample size was determined by data saturation, i.e., the point when the incremental learning from the data provided by the participants to answer the research questions and build theory is minimal (John W Creswell, 2013; Matthew

B Miles et al., 2013; Patton, 2002a). Based on this concept, a sample size of 20-30 individuals may suffice when using Grounded Theory (Charmaz, 2014; John W Creswell, 2013). In Malawi, the study was undertaken with 24 PLHIV, including one deviant case. Eight HSAs also participated as key informants. In Thailand, 20 PLHIV, including two deviant cases, and seven PCs participated. In total, 32 participants were interviewed in Malawi and 28 in Thailand. Both sample sizes allowed us to reach saturation. Therefore, the results of the qualitative studies may be transferable to similar sociocultural contexts (John W Creswell, 2013; Matthew B Miles et al., 2013; Patton, 2002a).

Selection of nutrient supplements for qualitative studies

The products selected as potential nutrient supplements for the qualitative studies allowed us to investigate perceptions from the participants towards different food categories. The selected products had adjustable energy densities in the range of 300-500 kcal/100 g. This range of energy density is needed to meet the requirements of food supplements for preventing and treating undernutrition. The products also offered the possibility to add a premix of 22 micronutrients in ~1 RNI/100g. For Malawi, we used high-energy butternut biscuits; pillow-shaped cereals with chocolate-cream fill; fruit bars of sweet and sour flavor and a soft consistency; and a local chocolate milkshake. For Thailand, we used the same type of cereals and fruit bars; a local snack made with peanuts, sesame seeds, and honey (Krayasat); instant noodles; and a local yogurt drink. We chose the preferred product type (i.e., a thick beverage of sweet and sour flavor) for subsequent development of the nutritious drink. The next studies were conducted in Malawi. We prioritized Malawi due to the high prevalence of HIV, food insecurity and undernutrition.

What could we have done better?

The validity of qualitative studies can be strengthened if a triangulation of investigators and methods is also used for the design of the study, data collection, and data analysis (Matthew B Miles et al., 2013; Patton, 1999, 2002a). Although the study was designed with the active participation of three researchers, data collection and analysis were carried out by the principal investigator. The inclusion of more researchers during data collection and analysis could have contributed to reducing the risk of bias that may come from a single person supervising data collection and conducting data analysis. However, to reduce the risk of bias in our studies, we worked with five local

researchers with previous experience in qualitative inquiry. This allowed us to include the perspectives of researchers familiar with the socio-cultural context and to mitigate the risk of bias.

The quality of qualitative research can also be increased by including additional methods of data collection — for example, direct observations (DO) or focus group discussions (FGDs) (1-3, 5). In our studies, direct observation could have provided observable data on the experiences of PLHIV consuming foods and beverages in their households. However, DOs could have been perceived as invasive by PLHIV. FGDs could have allowed us to explore social norms around the consumption of food and nutrient supplement, or group trends toward the preferences for nutrient supplements (9). Yet, PLHIV avoid meeting with other people to prevent disclosing their HIV status and the consequent stigma (chapter 2 and 3). Based on the reflections above, we selected the IDI as the most suitable method for conducting the qualitative studies with PLHIV in Malawi and Thailand. These methods led to robust results.

Sensory studies

Three sensory studies were conducted. We first assessed the olfactory and gustatory (chemosensory) function of PLHIV and healthy adults. The chemosensory assessment aimed to identify potential alterations in the olfactory and gustatory function of PLHIV that could affect food enjoyment, and therefore, their preferences for food (Croy et al., 2014; Seo & Hummel, 2009). For this study, we used the validated Sniffin Sticks (T Hummel et al., 2007) and Taste Strips (Basile Nicolas Landis et al., 2009) The second sensory study consisted of assessing the acceptability of eight samples of the nutritious drink and on developing a sensory characterization of the samples with inputs from PLHIV and healthy adults. For this study, we used 7-point hedonic scales and check-all-that-apply (CATA) questions (Gastón Ares, Dauber, et al., 2014; G Ares & Jaeger, 2014; Reinbach, Giacalone, Ribeiro, Bredie, & Frøst, 2014). Using the hedonic ratings from the samples and the answers to the CATA questions, we conducted a penalty analysis (Gastón Ares, Dauber, et al., 2014) to identify directions for tailoring the sensory characteristics of three of the samples (those with the highest acceptance) to the preferences of PLHIV and healthy adults. In the third study, we compared—among PLHIV—the ad libitum intake (Blundell et al., 2010) of the nutritious drink with that of RUTF and SC, i.e., the two nutrient supplements commonly used for treating undernutrition among PLHIV in Malawi ((MOH). 2017), and other low-and middle-income countries (Saskia De Pee & Richard D Semba, 2010; De Pee, Taren, & Bloem, 2017).

Selection criteria for the participants of the sensory studies

We conducted the sensory studies with PLHIV from clinical stages 1 and 2, as defined by the World Health Organization(Kassa et al., 1999). PLHIV from stage 1 may be asymptomatic or present minor health challenges such as enlarged lymph nodes. PLHIV from clinical-stage 2 may present moderate unexplained weight loss (<10% of the presumed or measured weight), recurrent respiratory tract infections or dermatological problems such as mouth sores, herpes zoster, among others. The majority of participants had a BMI ≥ 17 and ≤ 25 kg/m2. All the participants lived in rural communities located in Blantyre district, Malawi, and were representative of low-income consumers. These characteristics made participants eligible for receiving nutrient supplements for the prevention and treatment of undernutrition.

For the chemosensory assessment, we matched PLHIV and healthy adults for their sociodemographic characteristics, except for education. We could not find participants with a similar educational background in both population groups. For the study using CATA questions, we recruited PLHIV and healthy adults with similar demographic characteristics to investigate whether significant differences in preference for the nutritious drink samples would emerge between both groups. The study used to compare the ad libitum intake of the nutritious drink, RUTF and SC porridge was undertaken only with PLHIV because the nutritious drink was primarily developed for them. The results of our studies may be transferable to individuals with similar cultural, demographic, and health characteristics.

Sample sizes for the sensory studies

One-hundred PLHIV and 100 healthy adults participated in the olfactory and gustatory assessment. The sample size was more extensive than sample sizes used for similar studies, i.e., ≤ 50 participants (Brody et al., 1991; Mattes et al., 1995; Raja et al., 2013; Zucco & Ingegneri, 2004). For the CATA study, 100 PLHIV and 98 healthy adults participated. Sixty to 80 participants are recommended to elicit stable sensory characterization of products when using CATA questions with untrained consumers, and when clear differences between samples exist (Gastón Ares, Tárrega, et al., 2014). For the study based on ad libitum intake of the nutritious drink, RUTF, and SC porridge, 54 PLHIV participated. This number of participants slightly exceeded the number required to conduct the study for a power calculation of 80 % at an level of 0.05. Fifty-four participants were sufficient to document differences in volume

intake, as well as caloric and nutrient intake between the nutritious drink, RUTF, and SC. Overall, our sample sizes were adequate to obtain robust results.

The nutrient supplements for the sensory studies

For the study on the acceptability and sensory characterization of products with CATA questions, the objectives were to provide the consumers with a range of options (eight samples) that could allow us to identify the best product, the sensory characteristics that drive the likings and dislikings toward the samples and to identify directions for optimizing 1-3 samples of the nutritious drink. For sensory profiling studies conducted with CATA questions and untrained consumers, using five to 12 samples is recommended to obtain stable configurations of products represented in sensory spaces (G Ares & Jaeger, 2014), e.g., in the correspondence analysis plots. Eight samples are also appropriate to identify significant differences between products and directions for optimizing them (Gaston Ares et al., 2010; Gastón Ares, Dauber, et al., 2014; G Ares & Jaeger, 2014; Meyners & Castura, 2014). With eight samples of the nutritious drink, we were able to identify the best product, elicit stable configurations of the products represented in different sensory spaces, and to generate clear recommendations for optimizing three samples of the nutritious drink (Chapter 5, Table 5.6). Also, the results from the correspondence analysis from PLHIV and healthy adults were relatively similar, indicating that the sensory characterizations of the samples were stable (Chapter 5). Furthermore, clear and significant differences were found between the acceptability ratings of most of the nutritious drink samples (Chapter 5, Table 5.3). The selection of the number and type of samples allowed us to obtain robust results.

For the study on ad libitum intake of the nutritious drink, RUTF, and SC porridge, our primary objective was to compare the intake of the three products among PLHIV. We used the nutritious drink sample with the highest acceptability rating, a RUTF, and SC. In Malawi, RUTF is used by the Ministry of Health for treating mild to moderate undernutrition among adolescents and adults, including PLHIV ((MOH). 2017). Alternatively, a fortified blended food—Likuni Phala—may be used (in combination with RUTF or alone) for treating undernutrition ((MOH). 2017). SC is comparable to Likuni Phala. Products such as RUTF and SC are also used by WFP, UNICEF, and various NGOs for treating and preventing undernutrition among different population groups in low- and middle-income countries, worldwide (Saskia De Pee & Richard D Semba, 2010). Therefore, our selection of nutrient supplements covered the most common type of products for treating and preventing undernutrition. For a detailed nutrient composition of the nutritious drink, RUTF and SC, the reader is referred to Chapter 6, table 6.2.

For both studies, the samples were presented in a monadic sequence, coded with three-digit random numbers (G Ares & Jaeger, 2014; Lawless & Heymann, 2010) and following a Williams Latin square design (Williams, 1949), i.e., complete randomized block design to avoid carry-over and position bias. In other words, this design prevented that the participants' responses could be biased by the unwanted influence of sensory characteristics of one product (e.g., sweetness) over the next product and that the first sample is perceived differently than subsequent samples, only due to its position in its order of presentation.

Interpretation of results

The findings of the qualitative investigations indicate that culture and psychosocial factors heavily influence the preference and acceptability of nutrient supplements in the form of food among PLHIV. These findings are in line with other studies that have demonstrated the influence of culture in shaping food preferences and food choices among people worldwide (Luis Cantarero et al., 2013; Prescott & Bell, 1995; Rozin & Vollmecke, 1986a). It has been also demonstrated that psychosocial factors are strong determinants of food choice and eating habits (Bandura, 2002, 2004; Connors et al., 2001). Our results also suggest that a culturally appropriate nutrient supplement that meets consumers' expectations may be well accepted, incorporated in PLHIV's eating habits, and frequently consumed. Furthermore, the qualitative findings suggest that a beverage may be better accepted than solid and semi-solid foods. The majority of PLHIV in Malawi and Thailand indicated a preference for a sweet and sour drink with a thick consistency. The findings of the qualitative studies may be transferable to populations with similar health and sociocultural characteristics, but not to other populations and sociocultural contexts where preferences for food and drinks are different.

The assessment of olfactory and gustatory function has four primary limitations. The cognitive effort required from the participants to take the olfactory tests was very high. On average, the participants needed 70 minutes to take the three olfactory tests (olfactory thresholds, discrimination, and identification test). The majority of participants indicated being tired after the first assessment. The second limitation was related to the odor identification test. At least half of the odors used for the odor identification assessment may have been challenging to recognize for the majority of participants (Chapter 4). The third limitation is related to the education level of PLHIV and healthy adults in the study. The majority of them had a low education level. A low education level has been associated with lower performance in olfactory tests (Hoffman, Rawal, Li, & Duffy, 2016; Larsson, Nilsson, Olofsson, & Nordin,

2004), particularly in the odor identification test. (Dulay, Gesteland, Shear, Ritchey, & Frank, 2008; Larsson et al., 2004). Furthermore, in our sample, we could not match the level of education of PLHIV and healthy adults, which also contributed to a lower quality of the data. With these considerations, the results of the olfactory assessment may underestimate the olfactory function of PLHIV and healthy adults, hence, they should be interpreted with caution. Yet, in line with other studies (Brody et al., 1991; Fasunla et al., 2016; Zucco & Ingegneri, 2004), we found that PLHIV may experience olfactory loss.

Considering the limitations above, we do not recommend using 'Sniffin' Sticks in socio-cultural contexts where the testing procedures may be burdensome for the participants and where the odors for the identification test are not familiar for the respondents. Also, we do not recommend using 'Sniffin' Sticks' with people with a low education level due to the high cognitive demand and a long attention span required for the olfactory tests.

Regarding the evaluation of the gustatory function, we did not observe that participants had difficulty with the test. The majority of participants correctly identified the four taste qualities (sweet, salty, bitter, and sour). Most of PLHIV and healthy adults scored within normal ranges of gustatory function. In agreement with other studies (Frasnelli et al., 2016; Mattes et al., 1995), we did not find significant differences between the gustatory function of PLHIV and healthy adults.

Findings from the study on sensory acceptability and characterization of the nutritious drink samples using CATA questions indicate that PLHIV and healthy adults highly appreciated a drink with a thick-liquid consistency, fruity sweet and sour flavor, and a milky taste. The findings from this study confirmed the preliminary results of the qualitative inquiry conducted in Malawi and added detail concerning the sensory properties that drive the liking and disliking towards the nutritious drink samples. Optimizing three samples of the nutritious drink following the recommendations from penalty analysis, including the addition of two new flavors (banana and strawberry), may contribute to increasing the reward value for the nutritious drink, add variety to consumers' diet and foster a frequent consumption of the product (Zandstra et al., 2000). PLHIV and healthy adults may equally accept the three optimized samples. The large sample size of this study and the robustness of the results give us the confidence to conclude that adults, with and without HIV, can well accept the nutritious drink.

The results from the comparative study on the ad libitum intake of the nutritious drink, RUTF, and SC porridge show that the shorter oral residence time of the nutritious drink and its higher eating rate (g/min) led to a higher intake of food volume. Our results are consistent with findings from other studies that have

shown that the shorter oral processing/residence time of liquids leads to higher eating rates and to the consumption of larger volumes of food (de Graaf, 2011, 2012; Viskaal-van Dongen et al., 2011; Zijlstra et al., 2009). Furthermore, it has been shown that liquids have a larger bite-size than solid foods, which also contributes to the consumption of larger food volume (De Wijk et al., 2008; Zijlstra et al., 2009). In our study, the oral residence time of RUTF and SC porridge was significantly higher compared to that of the nutritious drink. The longer oral residence time of these semisolid products led to significantly lower eating rates and their lower intake. The results of our study suggest that due to a higher eating rate, liquid nutrient supplements may be more effective in treating and preventing undernutrition than semisolid products.

Implications of findings

The combination of qualitative research methods with methods from sensory science allowed us to successfully identify a nutrient supplement appropriate for adults and adults living with HIV and to tailor the sensory properties of the product to the preference of the potential consumers. Sensory sciences also contributed to elucidate that viscosity (liquid vs. solid) is a key determinant factor of the intake of nutrient supplements. The most relevant finding of our studies may be that the lower viscosity of the nutritious drink (compared to RUTF and SC porridge) led to the intake of a significantly larger volume of food and significantly higher quantity of micronutrients. However, it should be noted that the larger intake of micronutrients from the nutritious drink was also due to the larger quantities of micronutrients added to the product. Yet, our findings suggest that the use of beverages as vehicles for nutritional supplementation may have a better impact than semisolid products on the treatment of undernutrition. Specifically, the nutritious drink could benefit millions of people in Malawi and other sub-Saharan African countries, where similar forms of drinks are habitually consumed.

In sub-Saharan Africa, ~20 million people are HIV positive (UNAIDS, 2018), and ~346 million people live in conditions of severe food insecurity (FAO, 2018). The high prevalence of HIV and severe food insecurity suggest that the nutritious drink has enormous potential for improving the nutritional status, health, and quality of life of millions of people. Pregnant and lactating women (PLW) may be another target group that could also benefit from the nutritious drink, particularly in the third trimester of pregnancy and during lactation when nutrient requirements are higher. Nutrient composition for nutrient supplements for that target group has been proposed by an expert consultation held at the Bill and Melinda Gates Foundation (Saskia de Pee,

Kay Dewey, Edward Fischer, Alison Fleet, Nicolle Götz, Sheila Isanaka, Sarah Jensen, Ralph Jerome, Klaus Kraemer, Katharine Kreis, Mark Manary, Shahid Minhas, Saskia Osendarp, William Petri, Keith West Jr., Tahmeed Ahmed, & Christian, 2016). Per daily dose protein content should be 14-18 g (current protein content of the nutritious drink is 10 g/100 g); energy should be in the range of 250-500 kcal (the nutritious drink provides 370 kcal/100 g of powder); the Digestible Indispensable Aminoacid Score (DIAAS) should be ≥ 0.9 (current protein quality parameter for the nutritious drink is PDCAAS ≥ 0.75), and fat should provide 10-60 % of the energy with ≤ 1% of trans fats (the current fat content of the nutritious drink is 3 %). There is no specific recommendation for carbohydrate, but the WHO recommendation of limiting sugar intake at < 10 % of the total energy intake should be considered (WHO, 2015); Saskia de Pee, Kay Dewey, Edward Fischer, Alison Fleet, Nicolle Götz, Sheila Isanaka, Sarah Jensen, Ralph Jerome, Klaus Kraemer, Katharine Kreis, Mark Manary, Shahid Minhas, Saskia Osendarp, William Petri, Keith West Jr., Tahmeed Ahmed, & Christian, 2016). The recommended micronutrient content is equivalent to approximately 1 RNI for pregnant women (49).

While the nutritious drink is a promising nutrient supplement that can contribute to improving the nutritional status of millions of people, including PLW, it should be noted that because of the high eating rate of beverages, the consumption of this type of products could potentially also increase the risk for or contribute to overweight and obesity (de Graaf, 2011; Della Torre et al., 2016; Haddad et al., 2018; N. Olsen & Heitmann, 2009; WHO, 2015; Stratil et al., 2019; Viskaal-van Dongen et al., 2011). Therefore, its use is specifically recommended for populations who are at risk of or suffering from undernutrition, or populations with increased energy and nutrient requirements. This product would have to be used in moderation by people with micronutrient deficiencies who are also at risk of overweight and obesity, and it should not be used by people suffering from overweight and obesity.

Suggestions for future research

The nutritious drink should be optimized following recommendations from Chapter 5. Also, the product has some issues related to viscosity. We noted that the product's viscosity increases 10 minutes after its preparation. Adding amylase may fix this problem. We expect that optimizing the samples according to directions outlined in Chapter 5 may lead to a significant increase in the reward value for the product. Subsequently, the sensory acceptability of the optimized samples should be assessed. We propose to evaluate the acceptability of the three samples of the nutritious drink in three different population groups, i.e., PLHIV, healthy adults, and PLW.

We have been able to develop a palatable product of high acceptability. Palatability is positively associated with food and beverage choice and its frequent consumption (de Graaf et al., 2005). Furthermore, the nutrient composition and the average volume intake (ad libitum) of the nutritious drink suggest that the product could have promising results in treating and preventing undernutrition. Nevertheless, the efficacy of the nutritious drink still needs to be tested. The three optimized samples with different flavors should be tested in an efficacy trial (Habicht & Pelto, 2014; Stoltzfus, 2014). A randomized controlled trial comparing the impact of the nutritious drink on the nutritional status of PLHIV (and/or other target populations) with the impact of RUTF and SC is recommended to elucidate which of the products is more efficacious.

CONCLUSIONS

Using qualitative research, we have identified a beverage of frequent consumption in Malawi, i.e., Maheu. We used Maheu as a benchmark for developing the nutritious drink for nutritional supplementation. The product is appropriate for adult consumers living in Malawi and might be also well accepted by consumers in other sub-Saharan African countries. Using research methods from sensory science, we studied the acceptability and perceptions of adults, mainly adult PLHIV, towards eight samples of the nutritious drink and we elicited clear recommendations for further tailoring three samples of the nutritious drink to the preferences of adults and adult PLHIV. Applying these recommendations may contribute to a significant increase in the reward value for the nutritious drink, which may foster its continued frequent consumption. Our findings also provide relevant information on the potential of beverages for treating undernutrition. We have demonstrated that the nutritious drink has a higher eating rate, which leads to the consumption of a larger quantity compared to RUTF and SC. Our findings suggest that food supplements in liquid form may be more effective for treating and preventing undernutrition than semisolid products. However, the efficacy of the nutritious drink still needs to be tested.

References

(MOH)., M. o. H. (2017). National Guidelines on Nutrition Care, Support, and Treatment (NCST) for Adolescent and Adults. (Second edition ed., pp. 27). Lilongwe, Malawi: MOH.

Ares, G., Barreiro, C., Deliza, R., Giménez, A., & Gambaro, A. (2010). Application of a check all that apply question to the development of chocolate milk desserts. *Journal of Sensory Studies, 25*(s1), 67-86.

Ares, G., Dauber, C., Fernández, E., Giménez, A., & Varela, P. (2014). Penalty analysis based on CATA questions to identify drivers of liking and directions for product reformulation. *Food Quality and Preference, 32*, 65-76.

Ares, G., & Jaeger, S. (2014). Check-all-that-apply (CATA) questions with consumers in practice. Experimental considerations and impact on outcome. *Rapid Sensory Profiling Techniques: Applications in New Product Development and Consumer Research*, 227-245.

Ares, G., Tárrega, A., Izquierdo, L., & Jaeger, S. R. (2014). Investigation of the number of consumers necessary to obtain stable sample and descriptor configurations from check-all-that-apply (CATA) questions. *Food Quality and Preference, 31*, 135-141.

Bandura, A. (2002). Social cognitive theory in cultural context. *Applied Psychology, 51*(2), 269-290.

Bandura, A. (2004). Health promotion by social cognitive means. *Health education & behavior, 31*(2), 143-164.

Blundell, J., de Graaf, C., Hulshof, T., Jebb, S., Livingstone, B., Lluch, A., . . . Westerterp, M. (2010). Appetite control: methodological aspects of the evaluation of foods. *Obes Rev, 11*(3), 251-270. doi:10.1111/j.1467-789X.2010.00714.x

Brody, D., Serby, M., Etienne, N., & Kalkstein, D. S. (1991). Olfactory identification deficits in HIV infection. *Am J Psychiatry, 148*(2), 248-250.

Cantarero, L., Espeitx, E., Gil Lacruz, M., & Martín, P. (2013). Human food preferences and cultural identity: The case of Aragón (Spain). *International Journal of Psychology, 48*(5), 881-890.

Charmaz, K. (2014). *Constructing grounded theory*: Sage.

Charmaz, K., & Belgrave, L. (2002). Qualitative interviewing and grounded theory analysis. *The SAGE handbook of interview research: The complexity of the craft, 2*, 2002.

Connors, M., Bisogni, C. A., Sobal, J., & Devine, C. M. (2001). Managing values in personal food systems. *Appetite, 36*(3), 189-200. doi:10.1006/appe.2001.0400

Coyne, I. T. (1997). Sampling in qualitative research. Purposeful and theoretical sampling; merging or clear boundaries? *Journal of advanced nursing, 26*(3), 623-630.

Creswell, J. W. (2013). *Qualitative inquiry and research design: Choosing among five approaches*: Sage.

Croy, I., Nordin, S., & Hummel, T. (2014). Olfactory disorders and quality of life—an updated review. *Chemical senses, 39*(3), 185-194.

de Graaf, C. (2011). Why liquid energy results in overconsumption. *Proceedings of the Nutrition Society, 70*(2), 162-170.

de Graaf, C. (2012). Texture and satiation: the role of oro-sensory exposure time. *Physiology & behavior, 107*(4), 496-501.

de Graaf, C., Kramer, F. M., Meiselman, H. L., Lesher, L. L., Baker-Fulco, C., Hirsch, E. S., & Warber, J. (2005). Food acceptability in field studies with US army men

and women: relationship with food intake and food choice after repeated exposures. *Appetite, 44*(1), 23-31.

De Pee, S., & Semba, R. D. (2010). Role of nutrition in HIV infection: review of evidence for more effective programming in resource-limited settings. *Food and nutrition bulletin, 31*(4 suppl4), S313-S344.

De Pee, S., Taren, D., & Bloem, M. W. (2017). *Nutrition and health in a developing world*: Springer.

De Wijk, R., Zijlstra, N., Mars, M., De Graaf, C., & Prinz, J. (2008). The effects of food viscosity on bite size, bite effort and food intake. *Physiology & behavior, 95*(3), 527-532.

Della Torre, S. B., Keller, A., Depeyre, J. L., & Kruseman, M. (2016). Sugar-sweetened beverages and obesity risk in children and adolescents: a systematic analysis on how methodological quality may influence conclusions. *Journal of the Academy of Nutrition and Dietetics, 116*(4), 638-659.

Dulay, M. F., Gesteland, R. C., Shear, P. K., Ritchey, P. N., & Frank, R. A. (2008). Assessment of the influence of cognition and cognitive processing speed on three tests of olfaction. *Journal of Clinical and Experimental Neuropsychology, 30*(3), 327-337.

FAO, I., UNICEF, WFP and WHO. (2018). *FAO, IFAD, and WFP. The State of Food insecurity in the World 2018. Building climate resilience for food security and nutrition.* . Retrieved from http://www.fao.org/3/I9553EN/i9553en.pdf

Fasunla, A. J., Daniel, A., Nwankwo, U., Kuti, K. M., Nwaorgu, O. G., & Akinyinka, O. O. (2016). Evaluation of Olfactory and Gustatory Function of HIV Infected Women. *AIDS research and treatment, 2016*.

Frasnelli, J., Lague-Beauvais, M., LeBlanc, J., Alturki, A., Champoux, M., Couturier, C., . . . Tinawi, S. (2016). Olfactory function in acute traumatic brain injury. *Clinical neurology and neurosurgery, 140*, 68-72.

Habicht, J.-P., & Pelto, G. H. (2014). From biological to program efficacy: promoting dialogue among the research, policy, and program communities. *Advances in Nutrition, 5*(1), 27-34.

Haddad, L. J., Hawkes, C., Achadi, E., Ahuja, A., Ag Bendech, M., Bhatia, K., . . . Eriksen, K. (2018). *Global Nutrition Report 2018: Actions and accountability to advance nutrition and sustainable development*: Intl Food Policy Res Inst.

Hoffman, H. J., Rawal, S., Li, C.-M., & Duffy, V. B. (2016). New chemosensory component in the US National Health and Nutrition Examination Survey (NHANES): first-year results for measured olfactory dysfunction. *Reviews in Endocrine and Metabolic Disorders, 17*(2), 221-240.

Hummel, T., Kobal, G., Gudziol, H., & Mackay-Sim, A. (2007). Normative data for the "Sniffin'Sticks" including tests of odor identification, odor discrimination, and olfactory thresholds: an upgrade based on a group of more than 3,000 subjects. *European Archives of Oto-Rhino-Laryngology, 264*(3), 237-243.

Kassa, E., de Wit, T. F. R., Hailu, E., Girma, M., Messele, T., Mariam, H. G., . . . Coutinho, R. A. (1999). Evaluation of the World Health Organization staging system for HIV infection and disease in Ethiopia: association between clinical stages and laboratory markers. *Aids, 13*(3), 381-389.

Landis, B. N., Welge-Luessen, A., Brämerson, A., Bende, M., Mueller, C. A., Nordin, S., & Hummel, T. (2009). "Taste Strips"–a rapid, lateralized, gustatory bedside identification test based on impregnated filter papers. *Journal of neurology, 256*(2), 242.

Larsson, M., Nilsson, L.-G., Olofsson, J. K., & Nordin, S. (2004). Demographic and cognitive predictors of cued odor identification: evidence from a population-based study. *Chemical senses, 29*(6), 547-554.

Lawless, H. T., & Heymann, H. (2010). *Sensory evaluation of food: principles and practices*: Springer Science & Business Media.

Mattes, R. D., Wysocki, C. J., Graziani, A., & Macgregor, R. R. (1995). Chemosensory function and diet in HIV infected patients. *The Laryngoscope, 105*(8), 862-866.

Meyners, M., & Castura, J. C. (2014). Novel Techniques in Sensory Characterization and Consumer Profiling.

Miles, M. B., Huberman, A. M., & Saldana, J. (2013). *Qualitative data analysis: A methods sourcebook*: SAGE Publications, Incorporated.

Olsen, N., & Heitmann, B. (2009). Intake of calorically sweetened beverages and obesity. *Obesity reviews, 10*(1), 68-75.

World Health Organization (2015). Sugars intake for adults and children. *WHO: Geneva, Switzerland*, 49.

Patton, M. Q. (1999). Enhancing the quality and credibility of qualitative analysis. *Health services research, 34*(5 Pt 2), 1189.

Patton, M. Q. (2002). *Qualitative research & evaluation methods : integrating theory and practice* (Fourth edition. ed.). Thousand Oaks, California: SAGE Publications, Inc.

Prescott, J., & Bell, G. (1995). Cross-cultural determinants of food acceptability: recent research on sensory perceptions and preferences. *Trends in Food Science & Technology, 6*(6), 201-205.

Quinn, P. M. (2002). Qualitative research and evaluation methods. *California EU: Sage Publications Inc*.

Raja, J. V., Rai, P., Khan, M., Banu, A., & Bhuthaiah, S. (2013). Evaluation of gustatory function in HIV infected subjects with and without HAART. *Journal of Oral Pathology & Medicine, 42*(3), 216-221.

Reinbach, H. C., Giacalone, D., Ribeiro, L. M., Bredie, W. L., & Frøst, M. B. (2014). Comparison of three sensory profiling methods based on consumer perception: CATA, CATA with intensity and Napping®. *Food Quality and Preference, 32*, 160-166.

Rozin, P., & Vollmecke, T. A. (1986). Food likes and dislikes. *Annu Rev Nutr, 6*, 433-456. doi:10.1146/annurev.nu.06.070186.002245

Saskia de Pee, Kay Dewey, Edward Fischer, Alison Fleet, Nicolle Götz, Sheila Isanaka, Sarah Jensen, Ralph Jerome, Klaus Kraemer, Katharine Kreis, Mark Manary, Shahid Minhas, Saskia Osendarp, William Petri, Keith West Jr., Tahmeed Ahmed, , & Christian, P. (2016). *Framework and Specifications for the Nutritional Composition of a Food Supplement for Pregnant and Lactating Women (PLW) in Undernourished and Low-Income Settings: Report of an Expert Consultation held at the Bill & Melinda Gates Foundation*. Retrieved from

Seo, H.-S., & Hummel, T. (2009). Effects of olfactory dysfunction on sensory evaluation and preparation of foods. *Appetite, 53*(3), 314-321.

Stoltzfus, R. J. (2014). How can the scientific community support the generation of the evidence needed to improve the quality of guidelines for micronutrient interventions? *Advances in Nutrition, 5*(1), 40-45.

Stratil, J., Burns, J., Busert, L., Pfadenhauer, L., Polus, S., Holzapfel, C., . . . Rehfuess, E. (2019). Environmental interventions to reduce the consumption of sugar-sweetened beverages and their effects on health. *The Cochrane Database of Systematic Reviews, 6*(6), CD012292-CD012292.

UNAIDS. (2018). UNAIDS DATA 2018. 18, 20, 48.

Viskaal-van Dongen, M., Kok, F. J., & de Graaf, C. (2011). Eating rate of commonly consumed foods promotes food and energy intake. *Appetite, 56*(1), 25-31.

Williams, E. (1949). Experimental designs balanced for the estimation of residual effects of treatments. *Australian Journal of Chemistry, 2*(2), 149-168.

Zandstra, E. H., de Graaf, C., & Van Trijp, H. C. (2000). Effects of variety and repeated in-home consumption on product acceptance. *Appetite, 35*(2), 113-119.

Zijlstra, N., de Wijk, R., Mars, M., Stafleu, A., & de Graaf, C. (2009). Effect of bite size and oral processing time of a semisolid food on satiation. *The American journal of clinical nutrition, 90*(2), 269-275.

Zucco, G. M., & Ingegneri, G. (2004). Olfactory deficits in HIV-infected patients with and without AIDS dementia complex. *Physiology & behavior, 80*(5), 669-674.

Acknowledgments

The research presented in this thesis has been possible thanks to the collaboration of various people and institutions. Below, I acknowledge the persons that played a crucial role in the development of this work, my colleagues, and my family.

First, I would like to thank my mentor Dr. Saskia de Pee, and my promotor Prof. Kees de Graaf.

Saskia: many thanks for mentoring me along these years. I am grateful for your scientific guidance, as well as for the critical inputs on the design and implementation of research protocols, your advice in conceptualizing manuscripts, and your valuable contributions to this book. Also, I will always keep nice memories of the meetings that we had to taste the samples of the nutritious drink. Those samples that were made in DSM in Switzerland with raw ingredients imported from South Africa, and sent to Malawi for the subsequent sensory testing. We worked hard, but developing the nutritious drink was also fun. I am sure that we will keep in touch in the future. Thanks for making this Ph.D. possible, and above all, thanks for your friendship.

Kees: many thanks for giving me the opportunity to work with you these years and for introducing me to the world of sensory science. It was inspiring to learn from you, from your knowledge about nutrition and about your perspective on how and why sensory science should be integrated into international nutrition. Many thanks for your scientific guidance, critical inputs on research protocols, manuscripts, and for your advice on all chapters of this book.

To Stephen Kodish (Assistant Professor of Biobehavioral Health and Nutritional Sciences at Penn State University): Steve, thank you very much for mentoring me on the design and implementation of formative research. You are a professor with outstanding teaching skills. I enjoyed working with you, and hopefully, our lives will cross paths again.

To Nicolle Goetz (DSM): Nicolle, without you, the nutritious drink would not exist. Thanks for your enthusiasm, creative, committed, and hard work. I think that the adventures that we experienced with the development of the nutritious drink will keep a special place in our memories. I also want to thank you for being my paranymph! It was a nice surprise when you accepted my request!

To Dr. Klaus Kraemer (Sight & Life): Klaus, many thanks for believing in the nutritious drink, an innovative product, as you call it. Your positive feedback to the reports of the qualitative research was inspiring and paramount for continuing with the development of this product. Also, many thanks for making this book possible!

To Sanne Boesveldt: Sanne, many thanks for sharing your passion, knowledge, and enthusiasm for olfactory science. Thanks for your guidance on the conduct of the study on olfactory and gustatory function among people living with HIV (Chapter 4), for your support with data analysis and your inputs on the manuscript.

To Betina Piqueras Fiszman: Betina, thank you for guiding me on the design of the study on perceptions and acceptability of the nutritious drink (Chapter 5), your inputs on data analysis, and for your valuable contributions to the manuscript. Your advice was crucial for conducting a successful study.

To Ruth Stadler (Master Student WUR): Ruth, thanks a lot for your committed work, for supervising data collection in Malawi and for your support with data analysis. I enjoyed working with you!

To Dr. Mark Manary (Project Peanut Butter, Malawi, Professor of Washington University): Mark, thanks for your continuous support along these years, and thank you for opening the doors of PPB to me. This project would not have been possible without your help. Thanks for your critical inputs and positive feedback on all the manuscripts of the studies conducted in Malawi. I also want to thank you for all the logistical support that you gave us in Blantyre. It was also an enjoyable experience to meet your students and other collaborators of PPB in Blantyre.

To Drs. Chrissie Thakwalakwa and Minyanga Nkoma (College of Medicine of the University of Malawi): Chrissie, and Minyanga; many thanks for helping us getting the ethical clearance for the conduct of all the studies in Chilomoni Clinic and for contacting us with a great team of field researches.

To the field researchers from Malawi: Lameck Kachali, Maunice Mainga, Evelyn Kamwendo, Chimwemwe Nocas, Omega Mkandawire, Ulemu Kankwatira, Sheena Trinidad, Nthembwesha Katumbi, and John Lumbe. Many thanks for your great job in collecting the data for all phases of the study.

To Prof. Praphan Phanuphac and Ms. P' Non Supabhorn (Red Cross Anonymous Clinic, Bangkok, Thailand): Praphan and Non, thank you for supporting us with the conduct of the study on psychosocial factors influencing preferences for food and nutritional supplements among PLHIV in Bangkok, Thailand (Chapter 3). I also thank you for introducing me to the master students who conducted the interviews for the referred study.

To the master students from the Science Program in Nutrition and Dietetics of the Institute of Nutrition, Mahidol University, Thailand: Alongkote Singhato, Wacharin Suksanan, Natthaphon Thatsanasuwan, and Haneefah Wangsoh.

Many thanks for your dedicated and great job!

To my colleagues Lupita, Aregash, Maria, Umi, Taymara, Eric, and Liangzi: It's been lovely to meet you and spend time together over these years. I enjoyed your company in our small office.

To Paul, my paranymph and colleague: Paul, many thanks for being my paranymph, and many thanks for the nice coffee breaks! You and I inaugurated the high-quality coffee corner at Helix! Thanks for the nice moments, chats and beers as well.

I want to thank my family for all their support along these years. Doing this Ph.D., was a big challenge for myself, but also for my loved ones.

To my wonderful wife, Esther: Thanks for all your love expressed in multiple ways and for your unconditional support throughout these years. Thanks for always being there for Sebas and Emilia, mainly when I could not be with you due to the frequent and sometimes very long trips to Malawi and other countries. Thanks for giving me your support when I was overwhelmed with work and various challenges that we went through. Thanks for always being there next to me.

To my son Sebas (Cachito): thank you very much for your love and support and for filling my life with your sweetness and happiness. I will always remember you being next to me and hugging me while I was writing the last chapters of this book. Thanks for your love, kisses, and hugs, and your patience. You are just awesome!

To my daughter Emilia: Thanks for being so cheerful and nuts. Your laughs, craziness, and sweetness fill our home with joy and happiness. You are the most beautiful little bandida I've ever seen!

To my mom: my tireless, passionate learner. With your example, I have learned that loving what you do is the only way to be happy in life and to make your dreams come true. Thanks for always motivating me to be a curious and passionate learner and for stimulating me to use my knowledge to help others. your teachings and guidance will remain forever.

To my aunt: You are the toughest nicest person that I have ever met in my life. You have been a fantastic guide for my personal life and my career. Thanks for your unconditional love and support that you have given me since I have memory and before, and thanks for sharing with me all the best from you and your life.

A special thanks to my grandma that now rests in peace. If you could read this, I would like you to know that I admire you. You were one of the first women in Ecuador and the first woman in your city that went to university. That was exceptional in those days when attending the university for women was a challenge. Your strength, love, and example will always be part of me.

About the author

Santiago Rodas was born in Quito, Ecuador. He graduated as a Bachelor of Science in Human Nutrition at the University of San Francisco of Quito. Santiago started his career in nutrition as an intern at UNICEF Ecuador. After his internship, he became Nutrition Coordinator at the Health Division of the Municipality of Quito. One year later, he did an internship at the Pan-American Health Organization / World Health Organization (PAHO/WHO) in Washington D.C. where he designed a project for promoting physical activity and healthy eating in Quito. Some months later, Santiago became Chair of the Nutrition unit of Alimentate Ecuador (Feeding Ecuador) Program. A national food and nutrition security program that targeted infants, young children, and adults. Santiago coordinated the design and implementation of a nutrition program with three components: procurement and distribution of micronutrient powders, design, and implementation of a behavior change communication campaign (based on formative research) to promote breastfeeding and complementary feeding, and an innovative monitoring and evaluation system based on sentinel sites. After this experience, Santiago became consultant of UNICEF, Ecuador. His consultancy focused on supporting different government institutions in the design of the Strategy for the Reduction of Stunting and Anemia Prevalence among Children 6-59 months in Ecuador. In 2010, Santiago started a Master's program in Public Health Nutrition and Epidemiology at Wageningen University. As part of his Master's training, he did his Master's thesis and internship in the World Food Programme at its headquarters in Rome and WFP's Regional Bureau for Latin America and the Caribe in Panama, respectively. Upon completion of his Master's program, Santiago became consultant of the Nutrition Division of the WFP at its headquarters in Rome where he worked for six years. Santiago linked his main research project from WFP (development of the nutritious drink) to a Ph.D. Program at Wageningen University. Among other activities, he conducted formative research on eating practices of infants and young children in Pakistan, an acceptability study of nutrient supplements in Jordan, and a case study about a nutritional supplementation program in El Salvador. Currently, Santiago is doing a postdoc in food fortification and biofortification at Wageningen University.

Publications in peer-reviewed journals

Rodas-Moya, S., Kodish, S., Manary, M., Grede, N., & De Pee, S. (2016). Preferences for food and nutritional supplements among adult people living with HIV in Malawi. Public health nutrition, 19(4), 693-702.

Rodas-Moya, S., Pengnonyang, S., Kodish, S., de Pee, S., & Phanuphak, P. (2017). Psychosocial factors influencing preferences for food and nutritional supplements among people living with HIV in Bangkok, Thailand. Appetite, 108, 498-505.

Overview of completed training activities

Discipline-specific activities	Organizer and location	Year
Sensory evaluation and food preferences	University of Copenhagen, Copenhagen (DK)	2016
Sensory perception and food preference: affective drivers of food choice.	The Graduate School VLAG, Wageningen (NL)	2016
Sensory perception and food preference: the role of context.	The Graduate School VLAG, Wageningen (NL)	2018
European Conference on Sensory and Consumer research (Eurosense 2018)	ELSEVIER, Verona (IT)	2018
Workshop on global nutrition	WFP[1], Brindisi, Rome (IT)	2017
Workshop on Biofortification Monitoring, Evaluation, Learning and Impact Assessment	Harvest Plus	2019
General courses and workshops		
VLAG Ph.D. week	The Graduate School VLAG, Baarlo (NL).	2014
Ph.D. Workshop Carousel	WGS, Wageningen (NL)	2015
The Essentials of Scientific Writing & Presenting	WGS[2], Wageningen (NL)	2015
Scientific writing	WGS, Wageningen (NL)	2016
Presenting with impact	WGS, Wageningen (NL)	2016
Chemometrics	The Graduate School VLAG, Wageningen (NL)	2017
Applied statistics	The Graduate School VLAG, Wageningen (NL)	2017
Career perspectives	WGS, Wageningen (NL)	2018
Optional courses and activities		
Preparation of research proposal	WFP/WUR[3], Wageningen / Rome (NL/IT)	2014
Weekly Ph.D. lunch presentations	Sensory Science /Global Nutrition	2014- 2018

[1] World Food Programme
[2] Wageningen Graduate School
[3] Wageningen University and Research

Appendix 1

Technical specifications of the nutritious drink

TECHNICAL SPECIFICATIONS FOR
INSTANT NUTRITIOUS DRINK POWDER

Specification reference: **MIX --------**
Version: **DRAFT 5**
Date of issue:
Developed: **Charles JELENSPERGER, OSPFQ-WFP;**
Reviewed: **Saskia DE PEE, OSN-WFP; Santiago RODAS, OSN-WFP;**
Approved: **Shane PRIGGE, OSPFQ-WFP.**

1. INTRODUCTION

1.1 Product purpose

Instant nutritious drink powder is a food for special dietary use that is intended to supplement the diet of adolescents and adults as part of a nutritional program. One sachet contains one dose of **100g.** It is consumed as a drink just after mixing sachet content with **100 to 200** ml water that is safe for consumption. One sachet per day is recommended for maintenance of nutritional status (adds approximately 1 RNI of essential micronutrients to the diet) and two sachets per day for supporting recovery from malnutrition.

1.2 Product type

Instant nutritious drink powder is a fortified powder that is easy to mix with cold water at recommended dilution resulting in a beverage that is easy to drink and digest.

Instant nutritious drink powder is generally made from maltodextrin, sugar, corn, soybean, milk and milk derivatives, lactic acid, minerals, vitamins and flavors.

1.3. Quality and safety

Instant nutritious drink powder shall be manufactured within a quality and food safety

management environment in accordance with latest version of recognized international standards and best practices and/or guidelines, such as:

- Code of Hygienic Practice for Low-Moisture Foods: CAC/RCP 75-2015, of the Codex Alimentarius
- Recommended International Code of Practice. General Principles of Food Hygiene CAC/RCP 1-1969, of the Codex Alimentarius
- Commission Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs
- General principles for addition of essential nutrients to foods: CAC/GL 09-1987, of the Codex Alimentarius
- ISO 22000:2005: Food safety management systems
- ISO/TS 22004 – Guidance on the application of ISO 22000:2005

2. INGREDIENTS

2.1 Generic requirements

Instant nutritious drink powder shall be manufactured from ingredients that are fresh, of good quality, free from foreign materials and substances hazardous to health, that comply with Codex Alimentarius or relevant regulations. In particular, the latest version of the following standards and guidelines shall apply:

- USP food chemical codex for maltodextrin
- Codex stan STAN 153-1985 for maize that should be fully processed by extrusion cooking in order to reach targeted finished product properties
- Codex Stan 212-1999 for sugar
- Codex Stan 171-1989 for soybean that should be fully processed in order to reach targeted finished product properties. If soybean is processed together with maize, wet extrusion cooking is required.
- Codex Stan 207-1999 for milk powders
- Codex Guidelines CAC/GL 55 for vitamin and mineral premix
- Codex Committee on Pesticide Residues (CCPR)
- Codex Stan 193-1995 for all ingredients. In particular melamine shall remain below 2.5 mg/Kg in dairy source used: supplier shall test melamine at least once a year for each individual source of dairy protein used.

2.2 Vitamin and mineral premix

Instant nutritious drink powder shall include a premix consisting of the vitamins and minerals described in Table 1. Additionally the premix shall:

> Be purchased from GAIN Premix Facility or any of the GAIN approved suppliers, as per the list available at the following link: http://gpf.gainhealth.org/suppliers/current-suppliers

> Be delivered to the processor of Instant nutritious drink powder with a complete Certificate of Analysis. This document shall be presented to WFP with other documents for payment.

> Be stored as per manufacturer recommendations.

Table 1: Premix contribution and premix nutrient sources (approximate incorporation rate: 2.0%)

Nutrients	Unit	Recommended nutrient sources (/alternative options)	Nutrient added per 100g powder +/-10%
Retinol (Vit A)	mcg	Dry Vitamin A Palmitate 250 Cold Water Dispersible Stabilized / Dry Vitamin A acetate 325 Cold Water Dispersible Stabilized	880
Thiamin (Vit B1)	mg	Thiamine mononitrate	1.1
Riboflavin (Vit B2)	mg	Vitamin B2 fine powder	2.0
Niacin (Vit B3)	mg	Niacinamide	20
Pantothenic Acid (Vit B5)	mg	Calcium D Panthotenate	6.0
Pyridoxine (Vit B6)	mg	Pyridoxine hydrochloride	2.2
Biotin (Vit B7)	mcg	Biotin 1%	30
Folic acid (Vit B9)	mcg	Folic acid (adequate dilution)	250[1]
Cobalamin (Vit B12)	mcg	Vitamin B12 0.1% or 1% Spray Dried	3.2
Ascorbic acid (Vit C)	mg	Ascorbic acid	120
Cholecalciferol (Vit D)	mcg	Dry Vitamin D3 100 Water Dispersible Stabilized	17
Alpha Tocopherol (Vit E)	mg aTE	Dry Vitamin E Acetate 50% Water Dispersible	24
Phytomenadione (Vit K)	mcg	Dry Vitamin K1 5% Water Dispersible	44
Calcium (Ca)	mg	Dicalcium Phosphate Dihydrate / Dicalcium Phosphate Anhydre	300[2]
Copper (Cu)	mg	Copper sulphate anhydrous / copper gluconate	0.6
Iodine (I)	mcg	Potassium Iodide (adequate dilution)	200
Iron (Fe)	mg	5mg from Ferrous fumarate fine powder, 5mg from Iron-sodium EDTA	10
Magnesium (Mg)	mg	Magnesium sulphate monohydrate	25
Manganese (Mn)	mg	Manganese sulphate monohydrate	1.2
Phosphorus (P)	mg	Dicalcium Phosphate Dihydrate / Dicalcium Phosphate Anhydre	230[2]
Selenium (Se)	mcg	Sodium selenite / sodium selenate	50
Zinc (Zn)	Mg	Zinc Sulphate Monohydrate	19

[1]This is equivalent to 415 mcg DFE (dietary folates equivalent)
[2]This is equivalent to 1.3% of Dicalcium Phosphate Dihydrate

3. PRODUCT SPECIFICATION

3.1 Generic requirement

> Instant nutritious drink powder shall be microbiologically and chemically stable with a water activity between 0.2 and 0.3

> Instant nutritious drink powder shall have a neutral and homogeneous colour. Once prepared at recommended dilution (100g with 150ml cold water), it shall taste like non-alcoholic fermented maize beverage, slightly sour, not too sweet, including soft extruded maize particles (slight grittiness sensation) without sandy/ powder sensation. It shall remain liquid and easy to drink up to half an hour after preparation. As a starting point supplier could use the following recipe: maltodextrin (35%), instant extruded corn flour (22%), dextrose (17%), instant soybean meal (13%), milk powder (6.7%), lactic acid (3%), milk protein (2.2%), minerals, vitamins and flavours

> Instant nutritious drink powder shall be free from objectionable matter; free from micro-organisms in amounts which may represent a hazard to health; not contain any substances originating from micro-organisms or any other poisonous or deleterious substances such as residues of hormones, antibiotics, pharmacologically active substances, anti-nutritional factors, heavy metals or pesticide residues, in amounts which may represent a hazard to health of the specific population group for which they are intended such as people living with HIV or TB patients when 1 to 2 doses are consumed daily. In particular, it shall respect the following criteria:

- Total mesophilic aerobic plate count : max 100,000 cfu/g
- Enterobacteriaceae: max 1000 cfu/g
- Salmonella: absent in 5 samples of 25g
- Escherichia Coli: max 10 cfu/g
- Coagulase-positive Staphylococci: n:5, c:2, m:10 cfu/g, M:100 cfu/g
- Listeria Monocytogenes: max 100cfu/g
- Total aflatoxins (B1, B2, G1, G2): max 20 ppb
- Deoxynivalenol (DON): max 1000 ppb (1.0 mg/kg)

3.2 Nutritional value

Instant nutritious drink powder shall have a composition that is in line with Tables 2[3] and 4.

Table 2: Nutritional value at all points of time

Nutrients and nutritional values per 100g powder	Unit	Minimum	Label	Maximum
Water	g		NA	7
Energy	Kcal	375[4]	XX	
Protein	g	10	XX	15
Of which milk protein	g	4	NA	
Lactose	g	-	NA	2.5
Fat	g	3	XX	
Retinol (Vit A)	mcg	700	700	1400
Thiamin (Vit B1)	mg	1.0	1.0	
Riboflavin (Vit B2)	mg	1.8	1.8	
Niacin (Vit B3)	mg	18	18	
Pantothenic Acid (Vit B5)	mg	5.0	5.0	
Pyridoxine (Vit B6)	mg	2.0	2.0	
Biotin (Vit B7)	mcg	25	25	
Folates (Vit B9) DFE	mcg DFE	350	350	700
Cobalamine (Vit B12)	mcg	2.6	2.6	
Ascorbic acid (Vit C)	mg	100	100	
Cholecalciferiol (Vit D)	mcg	15	15	
Alpha Tocopherol (Vit E)	mg aTE	22	22	
Phytomenadione (Vit K)	mcg	40	40	
Calcium (Ca)	mg	620	620	
Copper (Cu)	mg	0.9	0.9	
Iodine (I)	mcg	200	200	
Iron (Fe)	mg	12	12	24
Magnesium (Mg)	mg	100	100	200
Manganese (Mn)	mg	1.6	1.6	
Phosphorus (P)	mg	450	450	
Potassium (K)	mg	400	400	
Selenium (Se)	mcg	55	55	
Zinc (Zn)	mg	20	20	40

[3]Two portions of the product per day (i.e. 200 g, or approx. 450 ml) in addition to the normal diet is intended to support recovery from malnutrition (low BMI) among adults, and provides 750 kcal and 80% of most micronutrients that are required from their total daily diet (assuming 2500 kcal). One portion (100 g, or approx. 225 ml) of the product provides approximately 1RNI of essential micronutrients and is intended to maintain nutritional status when consumed in addition to the daily diet. Levels of potassium, calcium and magnesium are set lower than the intended levels for taste reasons.

[4]Once prepared (100g powder with up to 200ml water), drink shall have an energetic density >1.2 kcal/g

3.3 Shelf life

Unless stated otherwise in the contractual agreement, Instant nutritious drink powder shall have minimum 24 months shelf life when stored up to 30°C at 65% relative humidity. A real-time shelf life study at 30°C or an accelerated shelf-life study at 40°C shall be initiated on each new formulation to confirm that:

- Food remains within maximum and minimum defined in Table 2
- Packaging as well as product color, taste and texture do not evolve; in particular there shall be no sign of oxidation.

4. PACKAGING AND MARKING

4.1 Packaging

Instant nutritious drink powder shall be packaged in food-grade sachets, under a modified atmosphere, hermetically sealed, and easy to open. The foil used shall have the following composition: PE60/Met polyester 12 or equivalent and adequate barrier properties to protect product from moisture, light, and Oxygen throughout its shelf life.

Instant nutritious drink powder shall be packed in cartons suitable for the humanitarian supply chain, each carton containing 150 individual sachets with a net weight of 100g each. Cartons shall be:

- New, manufactured from well-constructed double-walled corrugated board.
- With an edge crush resistance of 11 kN/m (61 pounds per inch) and a specific weight of 700 to 800 grams per square meter. 60% of the edge crush resistance shall remain at 90% relative humidity and 40°C.
- Fully filled for maximum strength.

Inside containers: slip sheets or plywood shall be used to provide maximum stacking strength. Pallets with appropriate stacking configuration could also be used.

4.2 Labelling

Instant nutritious drink powder shall be labelled in accordance with latest version of recognized international standards and best practices and/or guidelines, such as

- Codex Stan 146-1985 - General standard for the labelling of and claims for pre-packaged foods for special dietary uses.

> Codex Stan 1-1985 - General standard for the labelling of pre-packaged foods

In addition Instant nutritious drink powder shall be labelled in country of destination language as per Table 3.

Table 3: Generic label requirement:

	Sachets	Carton
Commercial name	Shall be kept simple and shall not reflect any medical purpose	
Product name	"Instant nutritious drink powder"	
Target use	"For special dietary use"	
Net weight	100g	150*100g (15 kg)
Nutrients content	In line with codex regulation and target defined in table 1	-
Ingredient list	XX[5]	-
Preparation instruction	"Add sachet content to a cup, fill the cup with water, mix, and drink. Only use water that is safe for consumption. Do not store once prepared" + Generic pictogram that shows how food is consumed.	-
Storage instruction	"Best stored below 30°C, in dry and hygienic conditions"	
Manufacturer name	Produced by: XX	
Manufacturer address	XX, including country of origin	
Manufacturer batch/lot number	XX	
Production date	XX	
Best Before Date	XX	
Other	"not for sale or exchange"	
Donor and WFP logo	As per contractual agreement	
Beneficiary feedback hotline	If required in the contractual agreement	

[5] All XX have to be filled by manufacturer

5. SAMPLING AND ANALYTICAL REQUIREMENTS

As per contractual agreement, WFP will appoint an inspection company that will check, based on the sampling plan defined below, that the food matches requirements specified in Table 4. Additional tests may be defined in case further quality assessment is required. This will be performed in addition to analysis conducted by the supplier according to his sampling plan.

5.1 Sampling plan

Sampling frequency (lot size) will be defined based on the daily production of the producer.

- For producers with daily production equal to or greater than 100MT, the inspection lot size will be one day's production.
- For producers with daily production less than 100MT, the inspection lot size will be one week's production.

The following number of samples representative of the inspection lot will be sent to the laboratory:

1. One set of samples for analysis 1-6 in Table 4 and for retention analysis
2. Five samples for microbiological analysis

5.2 List of analyses

Table 4: List of compulsory tests

No	Parameters	Limit	Method of analysis
1	Moisture	7.0 % maximum	ISO 712-2009
2	Protein	10-15 g/100g (N x 6.25)	AOAC 981.10 ISO 20483:2006
3	Organoleptic (smell, taste, color, texture)	Taste like non-alcoholic fermented maize beverage, slightly sour, not too sweet, including soft extruded maize particles (slight grittiness sensation) without sandy/ powder sensation.	100g mixed with 150ml cold water (no lumps)
4	Consistency (Bostwick flow rate)	min 150 mm/30s	100g mixed with 150ml cold water (no lumps)
5	Vitamin C	100-200 mg/100g	AOAC 2012.21 (HPLC) or titration,
6	Iron (Fe)	12-24 mg/100g	AOAC 944.02
7	Total Aflatoxin	Max 20 ppb	AACC 40-41B
8	Salmonella	Absent in 5 samples of 25g	AACC 45-16
9	GMO (Only if required)	Negative (< 0.9% of GMO material)	AACC 42-25B

COLOPHON

The research described in this thesis was financially supported by the **United Nations World Food Programme (WFP)** as part of its partnership with **DSM, Heerlen, the Netherlands, and by the Sight and Life Foundation.**

Financial support from **Wageningen University and Sight and Life** for printing this thesis is gratefully acknowledged.

Cover design and layout by Belen Mena, Belen Mena Design
Printed by ProefschriftMaken on FSC-certified paper.

Propositions

1. Local food culture is a crucial factor underlying the choice of food nutrient supplements.

   (This thesis)

2. Palatable nutrient-dense beverages lead to a higher intake of micronutrients than semisolid food supplements.
   (This thesis)

3. There is a high probability of getting incorrect research findings when the research methods are inadequate for the socio-cultural context where they are used.

4. Nutrient-dense food supplements with high caloric content may unintentionally contribute to overweight and obesity in food-insecure people living in low-and middle-income countries.

5. Weak political leadership, powerful commercial interests, and lack of demand for policy action from societies are critical causes of malnutrition worldwide.

6. Funding from the food industry is heavily skewing the research agenda in nutrition.

7. There is no boring place when you have a camera in your hand.

8. Wageningen University would benefit from having tastier coffee available for students and employees.

These propositions belong to the thesis entitled:

The Nutritious Drink:

a specialized nutrient supplement

for adults and adults living with HIV in Malawi

Santiago Rodas-Moya

Wageningen, 11 November 2019