Demand for Processed Indigenous Fruit and Vegetable Products – Insights from East Africa

Dissertation

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I have hated the words, and I have loved them, and I hope I have made them right.

The book thief

Summary

There is an increasing understanding that food systems need to provide not only calories but micronutrients as well. Simultaneously, consumption patterns are transforming around the globe. Convenience foods that are quick and easy to prepare are gaining more and more importance on the market. While these products provide fast access to carbohydrates that satisfy hunger, essential nutrients are often missing. In combination with an insufficient intake of fruits and vegetables (FV), this phenomenon leads to an undersupply of minerals and vitamins. This trend is observed in East Africa, despite the ample presence of highly nutritious FV growing naturally around the continent and is especially pronounced during lean seasons. The potential of indigenous plants is often neglected, and farmers experience significant postharvest losses of up to 50% due to inadequate access to processing knowledge and technologies.

Recent literature emphasizes the approach of processing highly perishable indigenous plants into more durable products to counter deficiencies in nutrient supply caused by postharvest losses and off-season gaps. However, processing will only be successful if the final products are regularly demanded and consumed. Insights into consumer perception towards processed indigenous FV (IFV) are rare. Few studies analyze consumer demand for value-added plants, such as sundried cowpea leaves, but only for a single, region-specific product at a given time. This misses the opportunity to draw a more comprehensive understanding of drivers that shape consumers' demand for processed IFV on a general basis. Additionally, while recent literature acknowledges the potential of value addition to improve income generation within local agriculture, there is a need to understand how to market processed IFV appropriately to derive benefits.

The present dissertation contributes to the existing literature by analyzing demand for several IFV products across East Africa and considering three bodies of literature: (1) addressing micronutrient deficiencies; (2) the growing demand for processed food products; (3) and improving the utilization of currently neglected plants, thereby lowering postharvest losses and bridging off-season gaps. The dissertation is part of the project "Fruits and Vegetables for all Seasons (FruVaSe)" that aims to process highly nutritious surplus FV into more durable products to improve access to nutritious foods. Food scientists of the FruVaSe project developed novel products obtained from underutilized

African plants. To our knowledge, this is the first study aiming to understand consumers' perceptions of several processed IFV products more comprehensively.

The dissertation consists of four papers based on a total of three consumer surveys that were conducted between October 2019 and March 2020. The surveys include consumers from rural and urban areas in East Africa. In total, we interviewed 1444 people across the region about eight products. The surveys include an economic investigation of consumers' willingness to pay (WTP) for the products combined with sensory testing. The target products include guava nectar and cowpea leaf soup mix in Kenya; dried cashew apples, African nightshade relish, dried African nightshade in Tanzania; and porridge combined with cowpea leaf powder, jackfruit-nut-bars, and jackfruit juice in Uganda. The IFV under investigation are highly nutritious and occur naturally in East Africa but are mainly grown on smaller scales, subject to significant losses, and rarely processed. In addition to providing general insights regarding consumers' demand for processed IFV, each paper carries unique contributions.

The first paper investigates consumers' demand for IFV products across rural and urban populations in Kenya, Tanzania, and Uganda. The objective of the analysis is to discern whether we can, in general, identify similar drivers shaping consumers' demand for processed IFV in these countries. To achieve this objective, the study combines sensory analysis with consumers' WTP. The research adds to the existing literature by combining several products and investigating three different countries. The results exhibit high scores for all sensory characteristics and similar socio-demographic drivers shaping consumers' demand across all three regions. Women, the elderly, and the rural population tend to be less willing to pay for the products. In contrast, younger, male, and urban participants show a higher WTP. The findings suggest that processing alone is not the solution to improve nutrition among the most sensitive population groups and interventions are necessary to enhance their demand.

The second paper evaluates marketing strategies for processed IFV. Value-addition is presumed to lead to higher incomes for farmers. We focus on the same sample discussed in paper 1. The objective of this paper is to improve the marketing of IFV products. We present different marketing options and discuss their suitability. The findings suggest that a reasonable share of participants are already willing to pay prices that exceed production

costs for most products. Still, marketing strategies are important to establish the products on the markets in the long run.

While the first two papers focus on introducing new products, the third paper explores consumers' demand for nutritionally enriched traditional porridges in Kayunga, Uganda. Porridge is already well established in the research area but is usually of low nutritional value. Previous research primarily focused on adding nutrients via biofortification. Combining traditional foods with local vegetables adds new insights. This paper aims to investigate maize and millet porridges combined with cowpea leaf powder as a channel to enhance the utilization of indigenous plants. We find that sensory perception is a significant determinant in shaping consumer demand for the products and that adding cowpea leaf powder lowers sensory perception. Still, almost half of the participants value the combined porridges as much as the plain ones. We conclude that enriching traditional porridges with cowpea leaf powder brings economic risks but can provide better nutrition for a specific consumer group.

The fourth paper analyzes the demand for jackfruit-nut-bars among students and staff of the Makerere University in Kampala, Uganda. The jackfruit-nut-bars can provide a healthier alternative to the currently consumed sugared snacks and can overcome the major obstacle hindering jackfruit consumption, namely its stickiness. Moreover, the results suggest that an acceptable sweetness of processed products can be derived without adding industrialized sugar.

In conclusion, our results demonstrate that processed IFV products are mostly well perceived among a reasonable share of people and can provide a new income source for small-scale farmers. Still, product-specific marketing strategies are indispensable for product implementation. Sensory perception is the most important factor explaining consumers' WTP, which aligns with previous findings on consumers' demand. We find similar factors driving demand across different products. Population groups that are more prone to micronutrient deficiencies, however, are more reluctant to pay. These findings call for interventions to raise familiarity with healthy processing and education campaigns informing about the importance of year-round consumption of nutritious foods.

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List of acronyms

BDM	Becker-DeGroot-Marschak
CLP	Cowpea leaf powder
FruVaSe	Fruits and Vegetables for all Seasons
FV	Fruits and Vegetables
IFV	Indigenous Fruits and Vegetables
JNB	Jackfruit-nut-bar
MP	Market Price
SDG	Sustainable Development Goal
WTP	Willingness to pay

1 General introduction

1.1 Background

As of 2021, nine years remain to achieve the United Nation's Sustainable Development Goals (SDG), which, among others, aim to achieve food security and improved nutrition (SDG 2), ensure healthy lives (SDG 3), and promote sustainable economic growth (SDG 8) and responsible consumption patterns (SDG 12). Still, in East Africa[1], between 56% (Tanzania) and 69% (Uganda) of the population faces at least moderately food insecurity, which indicates they are exposed to low-quality diets (The World Bank 2021). While the energy intake might be sufficient, the diets lack minerals and vitamins, such as iron, zinc, and vitamin A, essential for human development. The undersupply of these nutrients can lead to chronic diseases, such as cancer or heart diseases (Shenkin 2006).

Healthy, high-quality diets comprise year-round consumption of nutritious foods, including fruits and vegetables (FVs). However, projections suggest that except for Northern Africa, no region on the African continent can supply its population with the recommended 400 g of FVs per day (Gebremedhin and Bekele 2021). For instance, only 50% of the Kenyan population meets the recommended daily amount (Rousham et al. 2020). The severity of the situation in sub-Saharan Africa (GBD 2017 Diet Collaborators 2019) is particularly perplexing considering the vast prevalence of thousands of nutritious indigenous FV (IFV) plants across the continent (Chikamai, Eyog-Matig, and Mbogga 2004).

Beyond providing sufficiently nutritious food, food systems need to consider the growing population and the accompanying increase in food demand by 35% to 50% between 2010 and 2050 (van Dijk et al. 2021). Thus, meeting the SDGs requires reducing food loss and waste by at least 50% (FAO 2018). Globally, around 14% of food is lost between harvest and interaction with the final consumer. The FAO (2019) defines food losses as "the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retailers, food service providers, and consumers." The numbers are exceptionally high for FV in areas with an insufficient supply of cold storage

[1] In the context of this dissertation, East Africa refers to Kenya, Tanzania, and Uganda

facilities or inadequate postharvest handling techniques (FAO 2019). The FAO (2019) reports that sub-Saharan Africa loses nearly every second fruit or vegetable post-harvest.

One way to oppose these current trends is approaching insufficiently nutritious diets and high losses of FV simultaneously while considering local contexts (Ickowitz et al. 2019). In the face of climate change, the respective approaches need to be aligned with environmental sustainability to ensure long-term success (Crist, Mora, and Engelman 2017; Hertel 2015). In this sense, Willett et al. (2019) propose to provide nutritious foods from a broad spectrum of plants rather than further intensifying the production of only a certain limited set of crops.

Against this background, there is a growing body of literature describing the contribution of IFV, such as guavas (Omayio et al. 2019), African nightshade (Sangija, Martin, and Matemu 2021), and cowpea leaves (Owade et al. 2020a), towards food security. These IFV play an essential role in local diets as they are affordable, available, and rich in micronutrients (Aworh 2018; Kebede and Bokelmann 2016). Moreover, indigenous plants are often more stress-tolerant to extreme weather conditions such as long drought periods than exotic plants. Further, they can enhance farmers' resilience, offer additional income (Omotayo and Aremu 2020), and play an essential role in climate change mitigation (Baldermann et al. 2016).

Despite these broad benefits that IFV can provide, many species remain neglected and underutilized. Major obstacles hindering their utilization include lack of consumer awareness and change of preferences, loss of cultivation knowledge, and lack of processing techniques, with the latter causing significant postharvest losses (Kehlenbeck, Asaah, and Jamnadass 2013). One way to address all three obstacles concurrently is through certain methods of processing. Processing can enhance the shelf lives of IFV, thereby helping to improve the availability of nutritious foods, lower the pressure on natural resources, and enhance economies (Adeyeye 2017; Global Panel 2018). However, successful processing requires approaches specific to each region and resource while simultaneously considering consumer preferences (Augustin et al. 2016).

1.2 Processed food consumption in East Africa

Mirroring the global phenomenon, consumption habits in East Africa are changing towards more processed foods (Reardon et al. 2021). In rural areas, people purchase approximately 43% of the foods they consume, and, similar to urban areas, about 70% of

the foods purchased are processed. Economic and socio-demographic trends, such as urbanization and the increasing number of women working outside the home, shape the current development (Reardon et al. 2021). A recent study found that a purchase pattern is among the two most dominant consumption patterns among rural women in East Africa. The purchase pattern stands for highly processed foods, including ultra-processed foods and ultra-processed foods away from home. The authors find a positive association of the purchase pattern with overweight and obesity in Kenya and Tanzania, albeit not in Uganda (Sarfo, Pawelzik, and Keding 2021). The findings highlight the importance of considering the health aspects of processed foods.

Among the main factors that amplify this trend are the easy access to cheap edible oils and foods with empty calories and the growing distribution of modern supermarkets (Popkin et al., 2012, Rischke et al., 2015). While processed foods provide many benefits, such as easy and quick preparation (Sauer et al. 2021), they are not without health risks. The ingredients often contain high amounts of sugar, salt, and fat. Combined with an increasingly sedentary lifestyle, they add to the risk of non-communicable diseases such as hypertension and diabetes. The increase in processed food consumption has been going on for decades and is projected to rise further (Reardon et al. 2021). At the same time, more nutritious diets rich in legumes and vegetables are slowly disappearing (Popkin, Adair, and Ng 2012). Steyn & Mchiza (2014) emphasize the importance of counteracting this so-called nutrition transition to contain increases in diet-related health challenges that are already observed in the developed world, where the nutrition transition is far more progressed.

A method that allows meeting current demand and providing healthier alternatives to existing processed foods is the sensitive processing of IFV. However, there is little understanding of consumer perception of such products. So far, studies analyzing the consumption of value-added IFV focus on one product in a specific area (e.g., Mujuka et al., 2021; Okello et al., 2015). This misses the opportunity to establish a more comprehensive understanding of general factors driving consumers' demand for processed IFV in general. The results are somewhat diverse, without conclusive evidence on consumer characteristics that shape the acceptance of IFV products. Consequently, the question arises: Are processed fruit and vegetable products obtained from locally grown plants demanded by the East African population and can they, therefore, play an essential role in enhancing the dietary quality and lowering postharvest losses? This question is of

particular relevance to the research community, along with farmers, processors, and policymakers.

The present dissertation addresses this question as part of the project "Fruits and Vegetables for all Seasons (FruVaSe)." The project is in collaboration with the University of Nairobi, Kenya, the Nelson Mandela African Institution of Science and Technology in Arusha, Tanzania, the Makerere University in Kampala, Uganda, and the University of Applied Sciences in Erfurt, Germany. The project aims to provide year-round access to nutritious products obtained from underutilized IFV in East Africa through food processing and preservation. The target IFV are nutritionally promising, and the selected processing techniques are nutrition-sensitive. The project consists of five major work packages (Figure 1). This dissertation constitutes work package five (WP 5) and analyzes the marketing of processed IFV products in East Africa. It includes assessing consumer demand for a broad range of processed IFV products and analyzing how to improve marketing opportunities.

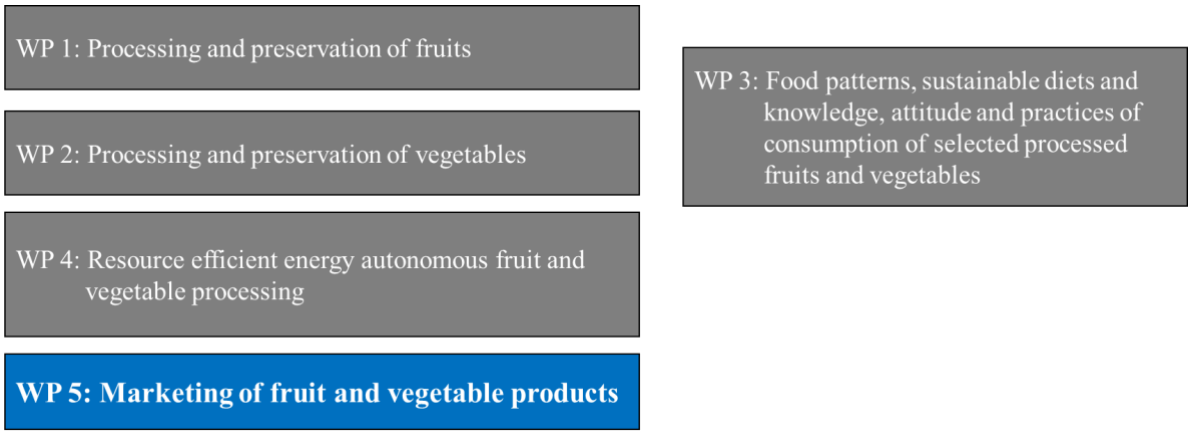


Figure 1: Overview of FruVaSe work packages (WP)

1.3 Defining processed foods

As mentioned that some processed foods are associated with dietary implications, it seems appropriate to elaborate on the term "processing" with specific regard to the target products to derive a common understanding of their value. Almost all food has undergone some form of modification compared to its natural state. Nevertheless, processed foods do not form a homogenous group, and increasing literature suggests a link between the magnitude of processing, dietary quality, and human health (Monteiro et al. 2018).

One of the most prominent approaches to classify food products based on their degree of processing is the NOVA system (Lawrence and Baker 2019). The system classifies foods either as (1) unprocessed or minimally processed (e.g., seeds, fruits, leaves), (2) processed culinary ingredients (e.g., oil, butter sugar), (3) processed foods (e.g., bottled vegetables, fruits in syrup), or (4) ultra-processed foods (e.g., soft drinks, sweet snacks) (Monteiro et al. 2018). Reardon et al. (2021) developed a similar categorization that is more practical to implement for foods in sub-Saharan Africa. They distinguish between (1) unprocessed foods (e.g., raw fruits or vegetables), (2) minimally processed single-ingredient foods with slight modification (e.g., flour, edible oil) (3) highly processed manufactured multiple ingredient foods (e.g., noodles, bread), and (4) ultra-processed foods and beverages with added salt, sugar, oil, or other ingredients to extend shelf lives (e.g., canned sodas, packaged cookies). They further divide ultra-processed foods into food consumed at home and food consumed away from home, with the latter gaining more and more importance in sub-Saharan Africa. Rapid changes in the food system that favor the spreading of ultra-processed foods and beverages are, for instance, associated with overweight and obesity (Popkin, Corvalan, and Grummer-Strawn 2019).

The main target products of this dissertation are displayed in Table 1. The project emphasized simple processing techniques that retain as many of the product's nutrients as possible. These techniques mainly include drying, pasteurization, and fermentation. These processes are minimal according to the NOVA classification. Nevertheless, some products (e.g., guava nectar and dried cashew apples) have characteristics that classify them as ultra-processed, such as added sugar, salt, and oil. However, unlike common ultra-processed products such as carbonated sodas or traditional mandaazi that do not provide nutritional benefits beyond energy, the target products of the project are rich in micronutrients such as iron, zinc, and vitamin C. Moreover, they do not contain food additives to increase palatability. Finally, while many sodas are entirely produced artificially, the target products of this dissertation are derived from natural products.

Ultimately, it is not possible to clearly classify the products used in the current dissertation based on the existing definitions of processed foods. Therefore, project colleagues are currently working on deriving their own classifications. For the terminological purposes of this dissertation, we will consider the products as processed (category 3 of the NOVA classification) or highly processed (category 3 of the scale by (Reardon et al. 2021)).

Table 1: Product overview of consumer survey (Paper 1 and Paper 2)

	Kenya		**Tanzania**			**Uganda**
	Cowpea leaf soup mix	**Guava nectar**	**Dried cashew apples**	**African nightshade relish**	**Dried African nightshade**	**Jackfruit juice**
						
	50 g	250 ml	50 g	50 g	50 g	300 ml
Ingredients	Cowpea leaves, starch, oil, salt, coriander, tomato, garlic, onions	Guava pulp, sugar, citric acid, moring leaf extract, preservatives	Cashew apples, sugar	African nightshade, sugar, lactic acid bacteria, oil, salt, garlic, pepper, turmeric, cardamon, onions	African nightshade, carrots	Jackfruit arils, sugar, preservatives
Main nutrients	β-carotene; Fe; Zn	Vit C; Fe; Zn; phytochemicals; β-carotene	Vit C; polyphenols; carotenoids	Vit C; β-carotene ; Fe ; Zn ; Ca	Vit B, Vit C; β-carotene	Vit A; Vit C
Shelf life of fresh produce (approximate days)	1 – 3	3 – 5	1	1 – 3	1 – 3	6
Shelf life of product (months)	5	3 – 5	6	n/A	6	6
Processing	oven-drying	pulping, pasteurization	solar-drying	fermentation	oven-drying	pasteurization
Place of consumption	home	anywhere	anywhere	home	home	anywhere
Sources	Owade et al., forthcoming	Omayio et al., forthcoming	Dimoso et al., 2020	Sangija et al., forthcoming	Kazois et al., forthcoming	Agaba et al., forthcoming

1.4 Research gaps

There is ample evidence on the nutritional value of IFV, high postharvest losses, widespread micronutrient deficiencies, and the transformation of consumers' demands towards more processed products. However, research linking all four areas is rare. We identified four relevant research gaps.

First, there is no common understanding of consumers' demand for processed IFV. Studies assessing value-added IFV focus on one product in one specific setting (Okello et al. 2015). Consequently, comparisons between different products are not possible drawing from existing literature, limiting the general understanding of consumers' demand for processed IVF products. This is a shortcoming because obtaining a holistic picture of demand for processed IFV products can support the successful future marketing of similar products. Second, studies promoting the processing of IFV to reduce postharvest losses often highlight the economic potential but fail to account for the consumer perspective. However, the products can only set foot in the market and survive if consumers demand them regularly and are willing to pay a price that exceeds the production costs. Third, several studies have assessed improving the nutritional value of conventional foods via nutrient fortification to counteract micronutrient deficiencies (Chowdhury et al. 2011; De Groote et al. 2020; Wanyama, Gödecke, Jager, et al. 2019). However, the existing studies did not focus on utilizing conventional foods as a channel to incorporate IFV into diets. Fourth, previous literature shows that snack consumption in Uganda can be valuable for cognitive and physical performance. Nevertheless, the intake of snacks is often viewed critically due to high amounts of sugar. Insight into the demand for healthy snacks that do not contain added sugars but derive their sweetness from natural ingredients is missing.

1.5 Research objectives and approaches

The dissertation comprises four research papers, which address the preceded research gaps. Table 2 shows an overview of the papers, including the locations where the underlying surveys were conducted, the target products, sample size, target population, methods, and statistics.

Table 2: Dissertation overview

	Paper 1	**Paper 2**	**Paper 3**	**Paper 4**
Title	Consumer demand for novel fruit and vegetable products with extended shelf lives in East Africa: A multinational multi-product analysis	Creating economic value for indigenous fruits and vegetables – Marketing insights from six processed products in East Africa	Improving the nutritional value of conventional food with underutilized leafy vegetables – Consumers' acceptance of combining porridge with cowpea leaf powder	Acceptability of jackfruit-nut-bars as a healthy snack in Uganda
Location	Kenya, Tanzania, Uganda	Kenya, Tanzania, Uganda	Kayunga, Uganda	Kampala, Uganda
Products	Cowpea leaf soup mix, Guava nectar, Dried cashew apples, African nightshade relish, Dried African nightshade, Jackfruit juice	Cowpea leaf soup mix, Guava nectar, Dried cashew apples, African nightshade relish, Dried African nightshade, Jackfruit juice	Millet porridge, Millet porridge combined with cowpea leaf powder, Maize porridge, Maize porridge combined with cowpea leaf powder	Four different types of jackfruit-nut-bars
Sample size[1]	1225	1225	126	93
Target population	Consumers at rural and urban open markets	Consumers at rural and urban open markets	Consumers at rural markets	Students and staff from Makerere University, Kampala
Methods	Becker-DeGroot-Marschak auction and sensory analysis	Becker-DeGroot-Marschak auction and production costs	Becker-DeGroot-Marschak auction and sensory analysis	Price sensitivity meter and sensory analysis
Statistics	Tobit models	Excel what-if analysis and logit models	Structural equation models	Random effect model

[1]before data cleaning

The first paper analyzes and compares consumers' demand and WTP for guava nectar and cowpea leaf soup mix in Kenya; dried cashew apples, African nightshade relish, and dried African nightshade in Tanzania; and jackfruit juice in Uganda. Further, we assess if additional information about the product's nutritional value, convenience, and shelf life enhance consumers' WTP. The study contributes to a more comprehensive understanding of what drives consumers' demand for processed IFV products. We focus on products that were obtained from locally available and underutilized IFV.

The second paper analyzes the benefits of IFV processing from a producer's point of view. We use the same data as in paper 1 and extend the scope also to include production costs. Combining consumers' WTP and production costs allows us to estimate the products' economic potential to add income for producers. In addition, we run a segmentation analysis to characterize consumers who are willing to pay optimal market prices on the one hand and those who are not on the other to obtain more in-depth knowledge on potential marketing strategies.

In the third paper, we take a closer look at the potential of enriching conventional maize and millet porridges with highly nutritious cowpea leaf powder as a channel to improve the utilization of cowpea leaves and improve access to nutritious food simultaneously. The study focuses on consumers at rural markets in Kayunga, Uganda. Similar to paper 1, we used WTP in combination with sensory analysis to approach our research question.

The fourth paper assesses individual sensory liking and WTP for jackfruit-nut-bars to facilitate the utilization of jackfruits. Challenges for the utilization of jackfruits are less dependent on seasonality but more on convenience due to the fruits' large size. Processed jackfruit products are still rare on the Ugandan market. Unlike the previous studies, we use the price sensitivity meter as a theoretical approach to elicit consumers' WTP. We analyze the demand for jackfruit-nut-bars as a snack for university students and staff.

This doctoral thesis proceeds as follows: Chapter 2 presents the first paper analyzing consumers' demand for processed fruits and vegetables in Kenya, Tanzania, and Uganda. Chapter 3, presenting the second paper, examines producer surpluses generated from selling processed products. The effect of combining conventional porridges with cowpea leaf powder is discussed in Chapter 4, the third paper. Chapter 5, introducing the fourth paper, analyzes the potential of jackfruit-nut-bars to lower jackfruit loss. Chapter 6 draws a broader conclusion based on all four papers. This Chapter 6 will also include an analysis

of general limitations of the research design and suggestions for future research. All three questionnaires and all information treatments are included in the general appendix.

2 Consumer demand for novel fruit and vegetable products with extended shelf lives in East Africa: A multinational multi-product analysis[2]

A similar version of this paper is accepted for publication in Public Health Nutrition

Abstract:

Micronutrient deficiencies in East Africa are most severe when fresh fruits and vegetables are out of season. Processing can bridge this gap, but there is no knowledge of consumers' demand for processed fruits and vegetables. Recent research describes the demand for nutritionally enriched products, but no focus has been placed on novel foods and analyzing impact factors among different products. The present survey combines sensory testing and experimental auctions to assess consumers' demand for six fruit and vegetable products in Kenya, Tanzania, and Uganda. We run tobit models and show that, besides sensory perception, similar socio-demographic characteristics influence consumers' willingness to pay. The results indicate that the products are demanded and especially liked among younger, male, and urban consumers. Interventions are needed to reach consumer groups that are especially prone to micronutrient deficiencies, such as women and the rural population.

Keywords: consumer demand, sensory analysis, willingness to pay, processed fruits and vegetables

[2] This paper is co-authored by Marwan Benali (MB) and Dominic Lemken (DL). JT and DL developed the research idea, JT collected the data, did the data analysis, and wrote the paper. DL commented at all stages of the research, MB commented on data analysis. MB and DL and contributed to writing and revising the paper.

2.1 Introduction

Malnutrition is still widespread in East Africa. Up to one fourth of the population is overweight, and one-fifth is at risk of dying from cardiovascular diseases. Concurrently, undernourishment in Kenya, Tanzania, and Uganda varies at approximately 35%, with more than 28% of women of reproductive age suffering from anemia due to iron deficiencies (World Health Organisation 2021). Fruit and vegetable (FV) intake, limited to only two to four times per week (USAID 2013), is low among the food-insecure population (FAO 2020). The findings of Keding, Schneider, and Jordan (2013) indicate that seasonality further impairs the population's nutritional status. In addition, high amounts of nutritious FV are lost due to improper storage and processing techniques. The FAO (2019) reports losses of up to 50% in sub-Saharan Africa. Compared to other foods, FV are especially impacted by losses due to their high perishability, which is exacerbated by the warm and humid climates in East Africa. A first pilot study finds a link between food losses and nutrient deficiencies in children in Kenya (FAO 2019). The study concludes that food loss reductions can respectively satisfy up to 24% and 33% of the iron and vitamin C requirements of children under five (FAO 2019). In Kenya, fresh FV, such as cowpea leaves and guavas, which are rich in nutrients (Omayio et al. 2019; Owade et al. 2020a), are lost due to poor postharvest handling techniques and processing. Major challenges include the short shelf life for fresh produce (e.g., a maximum of five days for guava) and inadequate preservation techniques (Omayio et al. 2019; Owade et al. 2020b).

The demand for processed fruit and vegetable products can contribute to lowering postharvest losses and improving nutrition simultaneously. Processing allows producers to diversify their income and provides consumers with access to nutritious food independent of the harvesting season. Van der Lans et al. (2012) emphasize the potential of processing to bridge seasonal nutritional gaps and lower postharvest losses. Furthermore, Okello et al. (2015) highlight the benefits of the solar drying of vegetables. It is an effective way to ensure year-round access to nutritious vegetables. Food processing can also help increase the likability of a fruit or vegetable, as evidence from Nigeria revealed astringent compounds in cashew apples as a major obstacle in acceptance (Nwosu, Adejumo, and Udoha 2016) and processing techniques being able to lower the astringency (Das and Arora 2017).

Moreover, processed FV fall into the currently undergoing shift towards more processed foods in Africa and globally (Baker et al. 2020). A review on dietary behavior in Kenya

finds that while FV consumption is low, sugar-sweetened beverages and processed/fried foods are widespread (Rousham et al. 2020). The current trend is predicted to cause considerable health burdens (Green et al. 2020). Processing FV sensibly could simultaneously appeal to consumers seeking ready-to-eat products and provide healthier alternatives for the sugar-sweetened beverages and snacks currently available in the market.

There are limited published data and evidence on the consumer evaluation of the sensory attributes of processed FV and their demand in East Africa. Okello et al. (2015) find that consumers' demand for processed cowpea leaves exists, but a large share of consumers are unaware of the benefits this product provides; their study targeted urban and peri-urban consumers. The demand will likely be different in rural, resource-poor households with less access to diverse markets. FV products can only contribute to overcoming seasonal gaps in micronutrient supply if they are accepted and regularly demanded and consumed.

The objective of the present study is to evaluate the potential of products made out of underutilized FV to close seasonal nutritional gaps among rural and urban consumers in East Africa. To respond to this challenge, food technologists and plant scientists have developed processed FV products that can bridge nutritional gaps and have extended shelf lives. The consumer demand for such products will be tested in this study. The test products include guava nectar, cowpea leaf soup mix, African nightshade relish, dried African nightshade, dried cashew apple, and jackfruit juice. The raw FV necessary for the products were selected due to their high nutritional values and current underutilization. Consumers from urban and rural areas will be targeted, and the location's influence will be assessed.

The remainder of the paper is organized as follows. Section 2.2 describes the methods applied in the study. The section includes a brief description of the products tested, the study site, the target populations, the sensory evaluation, the willingness to pay (WTP) experiment, and the empirical model. Section 2.3 will present the results, which will be discussed in Section 2.4. Section 2.5 concludes the paper. Section 2.6 presents the appendix with additional tables and figures.

2.2 Methods

2.2.1 Products tested

To address the research objective, six different fruit- and vegetable-based products were tested in Kenya, Tanzania, and Uganda (Table 3).

In Kenya, this included **guava nectar** and **cowpea leaf soup mix**. The guava nectar was prepared from guava pulp, moringa leaf juice extract, sugar, citric acid, and preservatives. Besides cowpea leaves, the soup contained a mixture of starch, coriander, tomato, onions, vegetable oil, and garlic. Both products were processed and packaged at the Department of Food Science of the University of Nairobi. The soup was prepared in the morning and stored in ThermoFlasks. For preparation, 50 g of soup powder was mixed with 10 ml of cold water. The mixture was set on a stove and another 490 ml of water was added. While stirring, the mixture was boiled for five minutes.

In Tanzania, an **African nightshade relish**, **dried African nightshade,** and **sun-dried cashew apples** were tested. All three products were processed and packaged at the Department of Food Biotechnology of the Nelson Mandela African Institution of Science and Technology in Arusha. The African nightshade relish was fermented and pepper, turmeric, garlic, cardamom, cooking oil, salt, onions, and carrots were added. The dried African nightshade was freshly prepared each morning in a traditional way before the experiments started. The dried leaves were fried in a pan using sunflower oil. Onions, green pepper, tomatoes, and yellow chili were added. The prepared dried African nightshade was then stored in hot pots and taken to the market. The cashew apples were blanched, sliced, immersed in 70% sucrose, and then sun-dried. The dried cashew apples are rich in carotenoids (0.28 g/100 g dry basis), vitamin C (0.73 g/100 g dry basis), and tannins (266.59 mg /100 g dry basis) (Dimoso, Makule, and Kassim 2020). The tannin content is significantly lower compared to the fresh fruit. The moisture content of the product is 13.81%. The nutritive value decreases over time but is still acceptable after 60 days (Dimoso, Makule, and Kassim 2020). The African nightshade and the dried cashew apples were stored in cool boxes.

In Uganda, **jackfruit juice** was tested. The juice was prepared using jackfruit pulp, preservatives, and sugar. Processing and packaging took place at the Department of Food

Technology and Nutrition at Makerere University Kampala, Uganda. The juices were stored in cool boxes during the day.

In all products, ingredients that can be harmful to human health when consumed excessively, such as sugar and salt, were kept low. Pre-trials were conducted for the guava nectar to determine the lowest level of sugar that the consumers accepted.

Table 3: Products tested by country

	Kenya			Tanzania		Uganda
	Cowpea leaf soup mix	**Guava nectar**	**Dried cashew apples**	**African nightshade relish**	**Dried African nightshade**	**Jackfruit juice**
Off-Season fresh produce	July to August October to March	July to February	January to September	June to December	June to December	none
Packaging	Kraft paper	Plastic bottle	Plastic bag	Plastic container	Plastic bag	Plastic bottle
Shelf life (months)	5	3-5	6	under analysis	6	6

2.2.2 Study site, setup, and participants

Data collection was conducted between October 2019 and February 2020 in Kenya, Tanzania, and Uganda. In total, 1225 participants were questioned. On several occasions, environmental influences, such as sudden downpours and strong winds, caused disruptions. To ensure validity, we dropped these days from the analysis. Some participants were dropped due to incomplete questionnaires. After data cleaning, 939 participants remained for further analysis.

Within all three countries, an urban and a rural area were selected to test the products. Both areas were chosen purposively, based on a justifiable effort to reach the target population. The major aim of the project was to bring nutritious products to rural areas, where micronutrient deficiencies are often more severe than in urban areas. However, when introducing novel products in the markets, it is often easier for producers to start distribution in urban areas, where the infrastructure is more advanced. In Kenya, Nairobi and the Taita-Taveta region were chosen to represent urban and rural consumers, respectively; in Tanzania, the Morogoro Municipal Council and the Morogoro District Council were selected, respectively; and in Uganda, Kampala and Kayunga were selected, respectively. Within each study region, respondents were targeted at open markets; within each region, four to five markets were selected due to their convenience aspects. Markets were defined as the usual place where many sellers met once or twice a week to sell their produce. Respondents were approached when leaving the market and independently of their gender, based on convenience aspects such as readiness to participate. Different markets were chosen to cover different market days (there was usually one market open per day) and to ensure that the respondents had not heard about the products already from family, colleagues, or friends.

Respondents had to meet the qualification criteria to participate in the survey. These criteria included being at least 18 years old, being free of diabetes and food sensitivities, possessing the responsibility to make food-purchasing decisions in the household, and being interested in testing the target products. All information was self-reported. However, the participants were informed that giving false information could be consequential to their health. Only respondents who met all the criteria were eligible. Qualified respondents were informed about their right to leave the survey at any time; they were also asked to give their written consent. Respondents agreeing to participate received a participation fee as a token of appreciation and to build their financial means

to participate in the auction. The participation fee was set at double the expected WTP. For example, in Kenya, the expected WTP for the guava nectar and cowpea leaf soup mix was 30 Kenyan shillings (KSH). This led to a participation fee of 120 KSH (1.16 US$). In Tanzania participants received 2,400 Tanzanian shillings (TSH) (1.05 US$) and in Uganda 4,000 Ugandan shillings (UGX) (1.08 US$). The exchange rates at the time of the study were used. The procedure was based on that used by De Groote et al. (2018). The enumerators started the survey with the sensory analysis.

2.2.3 Sensory testing

For sensory testing, consumers were asked to rate the products on a five-point Likert scale: 1 = dislike it very much, 2 = dislike it, 3 = neither like it nor dislike it, 4 =like it, and 5 = like it very much. The five-point Likert scale has already been applied in previous surveys in East Africa and was proven to be easier to understand by respondents with no or limited education (De Groote, Kimenju, and Morawetz 2011; De Groote et al. 2014). A small sample of each product was served in a plastic cup. Between products, respondents were asked to rinse their mouth with water. The product order was randomized to avoid first-sample bias. The tested sensory characteristics included color, aroma, texture in the mouth, taste, and general appearance.

2.2.4 Information treatment

After sensory testing and before the WTP analysis, every second participant received additional information about the products. Earlier studies on WTP for food products in East Africa found the provision of information to translate into higher WTP (Chowdhury et al. 2011; De Groote et al. 2014; Oparinde et al. 2016); the studies used different methods to present the information. To analyze the effect of the information, half the participants in each country were informed about the nutritional aspects and/ or convenience and shelf life characteristics of the products. We do not believe there were systematic differences between the two groups, although we have noticed tendencies in the sensory perception of the cowpea leaf soup mix and jackfruit juice, yet towards different sides (Table A. 1). As each product had its own specific characteristics, the given information differed. Besides information about the nutritional value of the products, participants were informed about the year-around availability of the product compared to the seasonality of the raw fruits and vegetables. The only exception was jackfruit juice, as jackfruits can be harvested year-round. In addition to the nutritional value information

and the shelf life benefits, information about the cowpea leaf soup mix, African nightshade relish, and dried African nightshade included convenience aspects, such as being able to prepare those products much faster and easier than preparing the fresh vegetables. The information was presented to the respondents using images. As an example, the information treatment for the cowpea leaf soup mix is presented in the Appendix Figure A. 1. The enumerators were carefully trained on how to explain the information.

2.2.5 Willingness to pay

A popular experimental method to assess consumers WTP is the Becker-DeGroot-Marschak (BDM) auction. BDM auctions offer the advantage of being individual. They are also less time-consuming and expensive than group auctions and can be conducted in the field at the point of sale (Morawetz, De Groote, and Kimenju 2011). Moreover, in contrast to theoretical mechanisms to elicit consumers' WTP, BDM auctions use real products and a real exchange of money and do not suffer from hypothetical bias; therefore, they are more accurate, and the results display market behavior better. Thus, the present study used the BDM auction method. The method was first described by Becker et al. (1964) and can be combined with sensory evaluation (e.g., De Groote et al., 2018). Moreover, BDM auctions have already been successfully implemented in developing countries as the procedure is easy to understand by less educated respondents (De Groote, Kimenju, and Morawetz 2011; De Groote et al. 2014).

The bid that a participant stated was compared to a randomly drawn price (Figure 2). The prices used depended on the market price of similar products. The highest number in the lottery equaled twice the estimated market price. This led to the following distributions. In Kenya, the estimated market price was 30 KSH for each product; thus, the prices in the auction ranged from 5 to 60 KSH. In Tanzania, the expected market price for each product was 400 TSH; thus, the prices in the auction ranged from 50 to 800 TSH. In Uganda, the estimated market price for the jackfruit juice was 1,100 UGX; thus, the numbers in the auction ranged from 200 to 2,200 UGX.

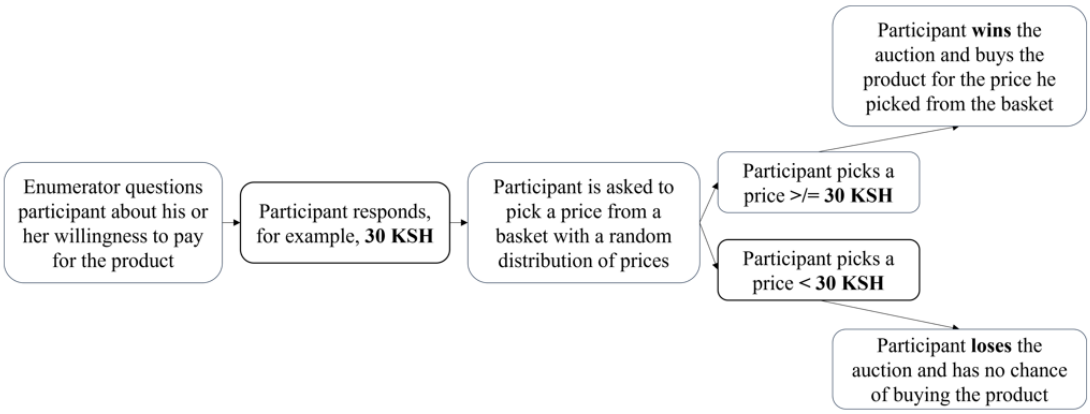


Figure 2: Brief scheme of the WTP auction

The WTP auction consisted of the following. First, the enumerators explained the general procedure which entailed the respondents being asked to place a monetary value on the products they just tasted in detail. The respondents were encouraged to ask questions about the procedure. To ensure that respondents understood the procedure correctly, they were questioned about different scenarios and could proceed only after they had answered correctly. The respondents were then shown the fully packaged products they had just tasted and asked to state a bid for each of them (e.g., 50 g cowpea leaf soup mix and 250 ml guava nectar). Next, they were requested to draw a number from a basket of numbers. The numbers were generated around the expected WTP. The highest number was double the expected WTP. If the number drawn by the respondent was lower or as low as their originally stated WTP, they won the auction and had to purchase the product. Otherwise, they lost the auction and had no chance of buying the product. The respondents were asked first to make bids for each of the products before drawing numbers to ensure that the outcome of the first products would not influence the bidding on the second product.

2.2.6 Empirical model

As participants could not state negative prices, we used a model that considered left-censored data. The tobit model applied in the present survey was first described by Tobin (1958). It models the relationship between a censored continuous dependent variable y^*_i and several independent variables x_i, where y^*_i is a latent variable observed for values

greater than 0. β is a vector of estimable parameters. In the present survey, y^*_i represented the WTP of participant i for one of the six products.

$$y_i^* = \beta x_i + \in_i \quad (1)$$

The dependent variable y_i was the WTP for each of the six fruit and vegetable products. The WTP was converted into dollars using the exchange rate at the time of the survey. To allow comparisons between the products, the purchasing power of each country was also considered, and the stated WTP was adapted accordingly. Therefore, the WTP in dollars was multiplied by the purchasing power parity (PPP) factor of each country, respectively. The respective conversion factors were calculated by dividing the countries' PPPs by the countries' gross domestic products. Data were obtained from the International Monetary Fund (2019). This led to a factor of 1.94 for the Kenyan products, 3.08 for the Tanzanian products, and 3.42 for the Ugandan product. To account for differences that may have occurred due to the different natures of the markets sampled, the error term was clustered at the market level. The enumerator effect was included as a control variable.

In total, eight variables were used to explain the WTP. The socio-demographic variables comprised age, sex, wealth, education, number of household members and location. Age was measured in years and grouped into quartiles (1 = 18 to 28; 2 = 29 to 38; 3 = 37 to 46; 4 = 46 and over). Wealth was an index that was calculated based on the World Food Programme's wealth index (World Food Programme 2017) and considered participants' ownership of livestock, land, access to water and sanitation facilities, and types of floor and wall materials. Education represented the highest education level of the participant (1 = none; 2 = primary; 3 = secondary; 4 = tertiary). Location indicated whether a participant was questioned in a rural or an urban setting. In addition to the sociodemographic variables, sensory perception and an information treatment dummy were included in the model.

To measure the impact of sensory perception, the five food attributes that were analyzed, namely, color, aroma, texture in the mouth, taste, and general appearance, were first condensed using principal component factor analysis with varimax rotation. For each product, one factor could be built out of the five characteristics (Table 4). The sampling adequacy was determined via Bartlett's test and the Kaiser-Meyer-Olkin (KMO) criterion. The internal consistency was determined via Cronbach's α. KMO values above 0.6 and Cronbach's α values above 0.5 were considered acceptable.

Table 4: Results of the factor analysis on sensory perception

Item	Guava nectar	Cowpea leaf soup mix	Dried cashew apples	African nightshade relish	Dried African nightshade	Jackfruit juice
Color	0.72	0.62	0.72	0.71	0.78	0.50
Aroma	0.68	0.77	0.76	0.77	0.78	0.64
Taste	0.75	0.86	0.71	0.81	0.82	0.61
Texture in the mouth	0.83	0.81	0.68	0.77	0.74	0.55
General appearance	0.80	0.84	0.72	0.81	0.84	0.71
Cronbach's α	0.80	0.84	0.76	0.83	0.85	0.55
KMO	0.79	0.83	0.78	0.83	0.82	0.68

2.3 Results

2.3.1 Respondent characteristics

The respondent characteristics were similar across all three countries. Overall, slightly more women participated in the survey than men (Kenya: 59 percent; Tanzania: 56 percent; Uganda: 57 percent). The respondents were young adults, with average ages of 36 years (Kenya), 39 years (Tanzania), and 37 years (Uganda), ranging from 18 to 88 years. All three countries have a young general population with average ages of 16 (Uganda), 17 (Tanzania) and 19 (Kenya) (Institute for Health Metrics and Evaluation 2018). In each country, the average family size was approximately four people. The education rate was slightly higher in Kenya than in Tanzania and Uganda. In Kenya and Uganda, more than 50% received at least a secondary education whereas in Tanzania, approximately 30% of the participants received at least a secondary education. Approximately half of the participants in each country were questioned in rural areas (Kenya: 52 percent, Tanzania: 53 percent, and Uganda: 46 percent). A Kruskal-Wallis test was conducted to determine if participants' sociodemographic characteristics differed significantly between the three countries. The test showed that there are differences between the countries in age, education, and number of household members. The participants in Tanzania were significantly older than the participants in Kenya and Uganda ($p = 0.001$ and $p = 0.002$, respectively). The Kenyan participants were living in household with less members than the Tanzanian and Ugandan participants ($p = 0.000$ and $p = 0.000$, respectively). The Kenyan and Ugandan participants were better educated ($p = 0.000$ and $p = 0.000$, respectively) and wealthier ($p = 0.000$ and $p = 0.000$, respectively) than the Tanzanian participants. In all three countries, nearly 50% of the participants received additional information about the products.

Moreover, we found sociodemographic differences between urban and rural participants. In Kenya and Uganda, the urban participants were significantly younger ($p = 0.021$ and $p = 0.036$, respectively) and were living with fewer household members ($p = 0.055$ and $p = 0.006$, respectively). The education rate was higher among the urban participants in Kenya and Tanzania ($p = 0.000$ and $p = 0.017$, respectively) and the urban participants were wealthier in Tanzania ($p = 0.000$) (Table A. 2).

Furthermore, we found sex differences. Significantly more men than women were questioned at urban markets in Uganda ($p = 0.000$). The female participants in Kenya and Uganda were significantly older than the male participants ($p = 0.013$ and $p = 0.015$, respectively), while the male participants in all three countries were better educated ($p_{Kenya} = 0.000$, $p_{Tanzania} = 0.073$, and $p_{Uganda} = 0.044$, respectively) (Table A. 3).

2.3.2 Sensory analysis

The results of the sensory analysis showed that all six products were predominantly perceived as positive in all five categories (Table A. 4). The products mostly received results of *like it* and *like it very much*. A Kruskal-Wallis test was conducted to determine the differences in liking between products. The test showed that there were significant differences in all categories, although not between all products in each category. The color of the cowpea leaf soup mix was rated significantly lower than the colors of the other products, except for the African nightshade relish. Both, the cowpea leaf soup mix and the African nightshade relish, had a deep green color. The yellowish color of the jackfruit juice was liked better than the color of any other product; the same result was found regarding the texture in the mouth and the taste of this product. Although sensory attributes were scored for most products and categories slightly higher among urban consumers, only a few differences were statistically different.

2.3.3 Willingness to pay

Following the sensory analysis for all respective products, respondents were asked to state their WTP. The products were fully packaged and shown without labels to the participants. The results showed a rather narrow distribution of the WTP for the cowpea leaf soup mix, dried cashew apples, African nightshade relish, and dried African nightshade, indicating that participants had rather homogeneous opinions of the products (Figure 3). The results for the jackfruit juice suggested quite different opinions about the

products among the participants. For all products, it seemed that participants have a more similar WTP among the lowest WTP quartile compared to the highest WTP quartile. The comparison between urban and rural consumers (Figure A.6) showed a statistically significant higher WTP among urban consumers for all six products.

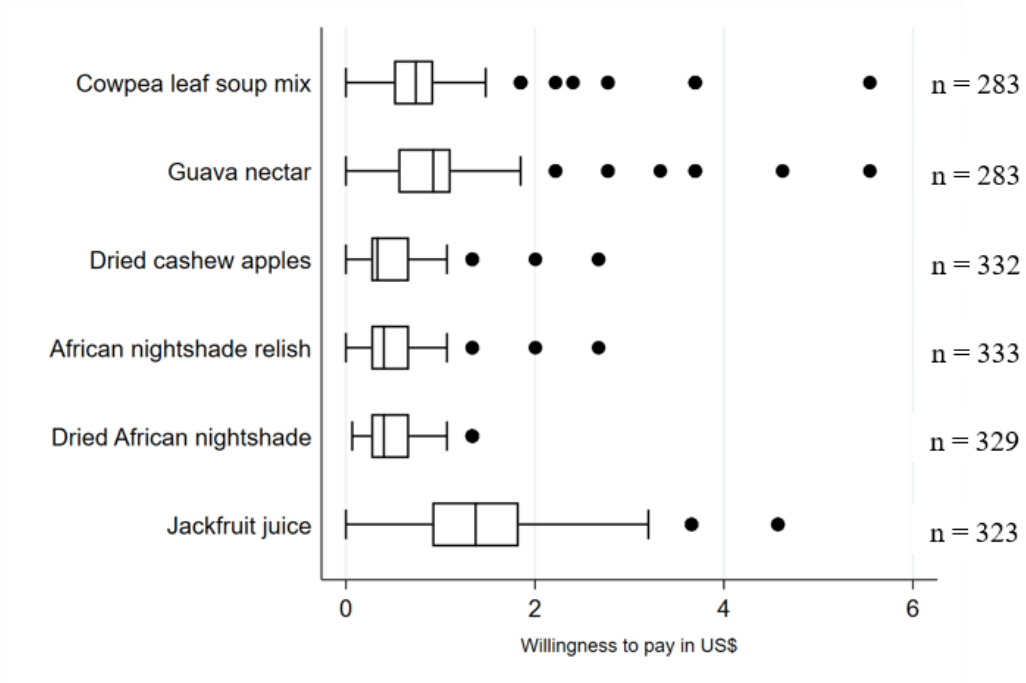


Figure 3: Mean willingness to pay for six fruit and vegetable products (values in US$, adapted by the purchasing power parity of the respective country where the product was tested)

2.3.4 Willingness to pay – Tobit model

To analyze the underlying factors influencing respondents' WTP, a tobit model was estimated for each of the products (Table 5). The results showed that a positive sensory perception translated into a significantly higher WTP for all the products but the dried African nightshade. This might be because the dried African nightshade was prepared in a traditional way, and once prepared, it did not differ much from the African nightshade that was not dried before preparation and commonly consumed in the area. This leads to the conclusion that African nightshade is not predominantly consumed for its taste. For most of the products, the WTP decreased as age increased. A statistically significant effect was shown for jackfruit juice and guava nectar where an increase in the age group lowered the WTP by 0.11 US$ and 0.07 US$ respectively. We find that there is a tendency for wealthier and better-educated participants to be willing to pay more for the products.

Additional information had a negative impact in all models except for guava nectar and cowpea leaf soup mix. The negative impact was statistically significant for the two African nightshade products. One reason could be that since these products are normally consumed in traditional settings, the information treatment may have triggered some lack of trust and, thus, resulted in a lower WTP. Being male increased the WTP in all models except for the model for dried African nightshade. The effect was found to be statistically significant for the dried cashew apples and the jackfruit juice, with marginal effects of 0.10 US$ for the dried cashew apples and 0.15 US$ for the jackfruit juice. For all products, the participants from urban areas were willing to pay more. The effect was especially strong for guava nectar. Being from an urban area increased the WTP by 0.47 US$. The number of people living in the household had a negative but not statistically significant effect for all products except the African nightshade relish. The interaction between wealth and sex decreased consumers' WTP for all products but the African nightshade relish. The effect was statistically significant for the jackfruit juice.

Table 5: Tobit analysis of respondents' WTP for fruit and vegetable products

	Kenya			*Tanzania*		*Uganda*
	Cowpea leaf soup	**Guava nectar**	**Dried cashew apples**	**African nightshade relish**	**Dried African nightshade**	**Jackfruit juice**
	Coeff. ± Std.	Coeff. ± Std.	Coeff. ± Std.	Coeff. ± Std.	Coeff. ± Std.	Coeff. ± Std.
Sensory analysis	0.173** ± 0.076	0.115* ± 0.068	0.044*** ± 0.016	0.027* ± 0.015	0.011 ± 0.023	0.073*** ± 0.026
(factor)	(0.024)	(0.090)	(0.005)	(0.084)	(0.632)	(0.005)
Age groups	-0.008 ± 0.031	-0.072* ± 0.043	0.013 ± 0.018	0.004 ± 0.008	-0.007 ± 014	-0.107*** ± 0.019
	(0.789)	(0.096)	(0.479)	(0.650)	(0.581)	(0.000)
Wealth (index)	0.224 ± 0.152	0.151 ± 0.195	0.109* ± 0.07	-0.011 ± 0.077	0.047 ± 0.054	0.432*** ± 0.061
	(0.142)	(0.440)	(0.098)	(0.888)	(0.386)	(0.000)
Received information	0.004 ± 0.115	0.149 ± 0.143	-0.013 ± 0.023	-0.076*** ± 0.029	-0.047* ± 0.028	-0.033 ± 0.041
	(0.973)	(0.299)	(0.567)	(0.010)	(0.089)	(0.412)
Education level	0.061 ± 0.038	0.095* ± 0.055	0.006 ± 0.044	0.032 ± 0.033	0.003 ± 0.022	0.027 ± 0.03
	(0.110)	(0.084)	(0.883)	(0.332)	(0.897)	(0.371)
Sex (female)	-0.182 ± 0.113	-0.112 ± 0.099	-0.101* ± 0.054	-0.02 ± 0.033	0.008 ± 0.037	-0.146*** ± 0.022
	(0.108)	(0.257)	(0.062)	(0.543)	(0.826)	(0.000)
Location (urban)	0.352* ± 0.195	0.469*** ± 0.136	0.028 ± 0.058	0.04 ± 0.049	0.064 ± 0.069	0.003 ± 0.068
	(0.072)	(0.001)	(0.632)	(0.417)	(0.349)	(0.961)
No. of household members	-0.035 ± 0.027	-0.029 ± 0.019	-0.009 ± 0.006	0.002 ± 0.007	-0.001 ± 0.005	0.001 ± 0.01
	(0.195)	(0.135)	(0.173)	(0.754)	(0.805)	(0.937)
Sex (female) #Wealth (index)	-0.125 ± 0.077	-0.105 ± 0.102	-0.055 ± 0.038	0.014 ± 0.037	-0.019 ± 0.045	-0.202*** ± 0.032
	(0.107)	(0.305)	(0.144)	(0.709)	(0.595)	(0.000)
N	283	283	332	333	329	323
Mean	0.94 ± 1.08	0.98 ± 0.83	0.49 ± 0.42	0.46 ± 0.46	0.54 ± 0.41	1.51 ± 1.16
pseudo R^2	0.139	0.089	0.133	0.296	0.164	0.079

p - values in parentheses * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$

2.4 Discussion

The main objective of this study is to assess consumers' demands for FV products in East Africa. Previous studies on this topic have demonstrated the power of combining sensory analysis and BDM to address the objective (De Groote et al. 2014; 2018). The most important finding of the present survey was the positive perception of different highly nutritious FV products across Kenya, Tanzania, and Uganda. Considering the nutritional benefits of these products, this offers a great opportunity to increase their consumption. The analysis of the factors explaining the consumers' WTP revealed several consistent findings among all six products. These are important results for further marketing and dissemination of the products. As expected, *sensory liking* had a high influence on consumers' WTP. This finding must be understood in the context of the mean sensory rating between *like it* and *like it very much*. Moreover, our results confirm the influence of socioeconomic factors on the WTP for FV products, which is consistent with other studies conducted in sub-Saharan Africa but to different extents (Okello et al. 2015; Senyolo, Wale, and Ortmann 2014).

While Okello et al. (2015) showed a higher WTP for value-added cowpea leaves among elderly people and women, the present survey found that *age* and being *female* negatively influenced the WTP for most of the surveyed products. This might be because the products being analyzed by Okello et al. (2015) were simply sun-dried and, thus, resembled the fresh produce more than the products in the present survey. This also goes in line with our finding that being female did not decrease the WTP for the dried African nightshade, which resembles the product analyzed by Okello et al. (2015). Hence, we can conclude that women prefer processed products less than men, although this is not necessarily a causal relationship. Additionally, Van der Lans et al., (2012) found that women, in general, consume more vegetables than men and might, therefore, have a lower need to enhance their consumption patterns by adding processed fruits and vegetables. We speculate that women place higher value on the raw material and prefer home preparation or processing of their food. Women are presumed to have higher culinary skills and thus, to be less dependent on ready-to-eat products. These are important findings as women are most vulnerable to micronutrient deficiencies (FAO 2020).

Unlike previous studies that showed that additional *information* can increase consumers' WTP for food products (Banerji et al. 2018; Oparinde et al. 2016), we found information to barely have an effect. The present survey presented information as a combination of

images and texts while previous studies used radio messaging or simple text and only focused on nutritional information. This finding highlights the importance of determining how nutrition information needs to be placed to appeal to consumers and concludes that the effect to be expected from before purchase information is limited at best. This issue that was already highlighted by Lagerkvist et al. (2016), who found that detailed information about nutritional benefits decreased consumer acceptance of biofortified orange-fleshed potato in Kenya.

According to the nutritional transition, food consumption in East Africa (and globally) has shifted towards more processed foods. This includes rising demand for food groups such as soups, nectars or fruit snacks, and products that were analyzed in the present survey (Baker et al. 2020; Green et al. 2020; Rousham et al. 2020). A major challenge of the current trend is the low nutritional value but high sugar and fat concentrations of many processed products and the consequential health issues (Baker et al. 2020). The products in the present survey fit into the current demand but also provide great nutritional value, as they are rich in micronutrients such as vitamin A, iron, and/or zinc. Undersupply of these nutrients can be observed in large parts of East Africa, and their sufficient intake is highly dependent on adequate dietary diversity (Development Initiatives 2018).

Consumers from *urban* areas, who are expected to have better access to and knowledge of already existing processed foods, were willing to pay more for the products. This finding is in contrast to findings for fresh vegetables (Gido et al. 2017), which show low acceptance of African leafy vegetables among urban dwellers. These findings also showed that taste hinders demand. Based on our findings, it seems that processing can overcome this obstacle. This finding is in line with previous studies demonstrating the potential of processing to enhance the acceptability of cashew apples (Das and Arora 2017). Knowledge concerning the preparation of fresh African leafy vegetables will likely be higher in rural areas; and thus, the need for processed products will be lower. However, as seasonality causes shortages in fresh produce and increases malnutrition (Keding, Schneider, and Jordan 2013), familiarity with processed products should increase in rural areas. As most of the products do not require difficult processing, it is also possible to educate rural consumers on the processing of healthy food items at the household level.

Additionally, *wealth* had a positive impact on the WTP, which highlights the importance of setting the price for the products carefully, to avoid excluding poorer households.

Finding profitable markets for new processors and simultaneously reaching the very poor with improved nutrition is a difficulty that was already emphasized by De Groote et al. (2018). They suggest that profitable enterprises should be established first among wealthier consumers and that successfully operations should allow them to reach poorer households. The technologies used to produce the products of the present study, however, were especially chosen because they can be easily implemented in rural settings, to improve nutrition among the most vulnerable population groups. Additionally, the raw material used for production can be sourced directly in the rural areas, and establishing enterprises in those regions will lower transportation costs, which will make the products affordable for the poor. It needs to be noted that according to the results of the interaction between wealth and sex, we find that the positive wealth effect is more pronounced for men.

The *number of family members* living in the household had a negative effect on the WTP. The products were packaged in small quantities and, thus, were unlikely to be sufficient for larger families. The packaging size had convenience purposes for the sake of this survey. Future selling in the market should provide different packaging sizes to appeal to different numbers of household members. Additionally, food preferences will vary more in larger families, thus making it more difficult to find a product that appeals to everyone.

The WTP also increased with *education*. Better-educated people are assumed to already have better knowledge of dietary health implications and are, thus, more interested in choosing healthy food.

Several limitations of the study need to be discussed. First, the results show tendencies for certain consumer groups but no constant statistically significant results. Further studies are necessary to confirm our findings. Second, the survey did not include children. As micronutrient deficiencies are also widespread among this population group (FAO 2020), future research could, for example, address possibilities to include the products in children's school food. Further subgroups such as pregnant women or women in childbearing age could also be of interest in future studies. Third, the study did not cover differences in the WTP between seasons. Assessing differences in perception between the lean and peak seasons may be an interesting topic in future research. Fourth, it might be possible that despite their limitations, the information treatments could be effective among subgroups, who are more pronounced to media channels or radio. This was,

however, not analyzed in the present study and should be considered in future research. Finally, it is important to note that while the products presented here are rich in nutrients, they play only one part to improve health and cannot erase malnutrition alone. They must be included smartly in the daily and healthy diets. Sarfo et al. (unpublished results) tested minimally processed fruits and vegetables, including cowpea leaf soup mix, in a modeled diet for women and children in rural Tanzania. In their results, the minimally processed fruits and vegetables substantially reduced the diet cost of women and children between 12 to 23 months. Additionally, nutrient gaps such as those for iron, zinc, vitamin A, vitamin C, and vitamin B2 were bridged with the addition of the minimally processed fruits and vegetables to the diets.

Moreover, we learned some lessons from the setup of the survey. While approaching people in open markets, we were able to question many participants, but the setup was highly subject to environmental effects. Sudden weather changes forced interruptions in questioning and aggravated the separation of waiting people from participants. To ensure independent results, many participants had to be dropped from the survey. In addition, participants came to the market to do their grocery shopping and were often in a hurry to finish the survey. It is, thus, recommended to preselect and invite consumers to less crowded and better controllable environments. This would also allow for a more sensitive selection of the participants to include representative numbers from different sociodemographic groups. The present survey is representative of the selected markets but not of the selected countries, so some caution about the external validity of the results should be considered.

2.5 Conclusion and policy implications

The sensory analysis indicated high appreciation for all six fruit and vegetable products and translated into higher WTP. We conclude that there is demand and a potential market for processed fruit and vegetable products based on indigenous raw materials in East Africa. The products, thus, have promising potential to improve nutrition, especially during off-season conditions when access to fresh produce is limited. Our analysis showed that similar sociodemographic characteristics influence the demand for the diverse spectrum of products analyzed in this study. While fresh African leafy vegetables are mostly consumed among elderly, poorer, and rural populations (Dube et al. 2018), processing enhanced acceptance among younger, wealthier, and urban dwellers. This

offers wider sales opportunities but also calls for careful marketing strategies to ensure inclusion of the most severely impacted populations. Surprisingly, image-based information on nutritional and/or shelf life benefits was not helpful to create additional demand. Future surveys should assess how to promote the products best. Additionally, the images must be adapted to anticipate current drawbacks.

To conclude, it is encouraging that the products were so well received, and many participants were willing to pay a reasonable price. To our knowledge, this is the first study that comprehensively analyzed consumer demand for six different products across three different countries. Our findings that women and rural participants, who are often most affected by malnutrition, were more reserved towards the products implies that sole processing is not the solution; we need to improve the perception among these population groups. We also found that younger, male, and urban consumers were more willing to buy the products. These groups are likely to have less knowledge of preparation and cooking techniques (Gido et al. 2017) and could, thus, greatly profit from processed fruit and vegetable products.

As we have shown consumers interest in nutritious fruit and vegetable products obtained from local plants, supporting this business should be interesting for policymakers. The products are suitable for diverse groups of the population, ranging from children to the elderly. However, our research showed that interventions are necessary to reach all consumer segments, especially those impacted most severely by micronutrient deficiencies. Women and the rural population were less interested in the novel fruit and vegetable products independent of wealth, although they are more often deficient in some of the micronutrients the products offer. Community events can be an opportunity to advertise the products, how they are created, and raise familiarity among the rural population. Additionally, educating women on processing techniques could improve dissemination and acceptance among this consumer group.

Considering that sensory characteristics played a significant role in shaping consumer demand, supporting research on product development might enhance the utilization of these fruits and vegetables. It is important to note that all government support of fruit and vegetable processing should be linked to retaining health aspects in the final products.

2.6 Appendix

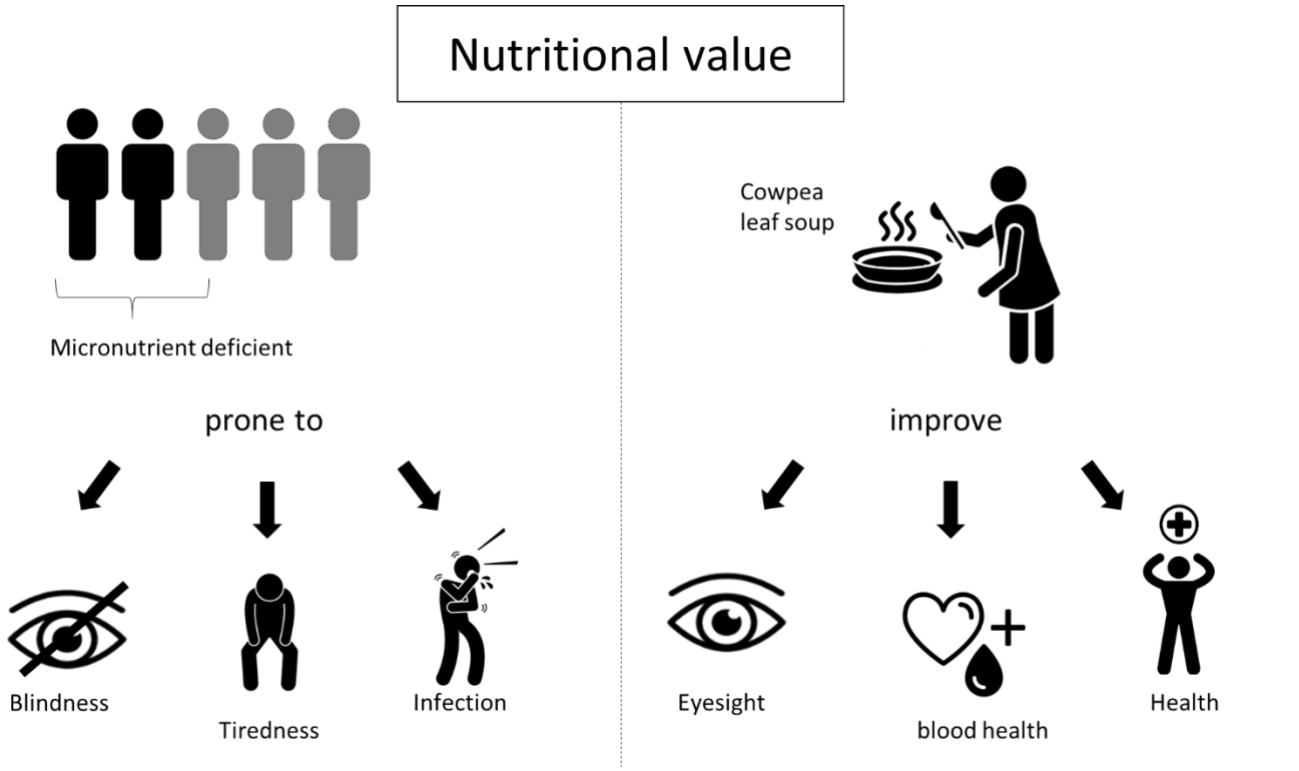
Table A. 1: Participant characteristics, by information

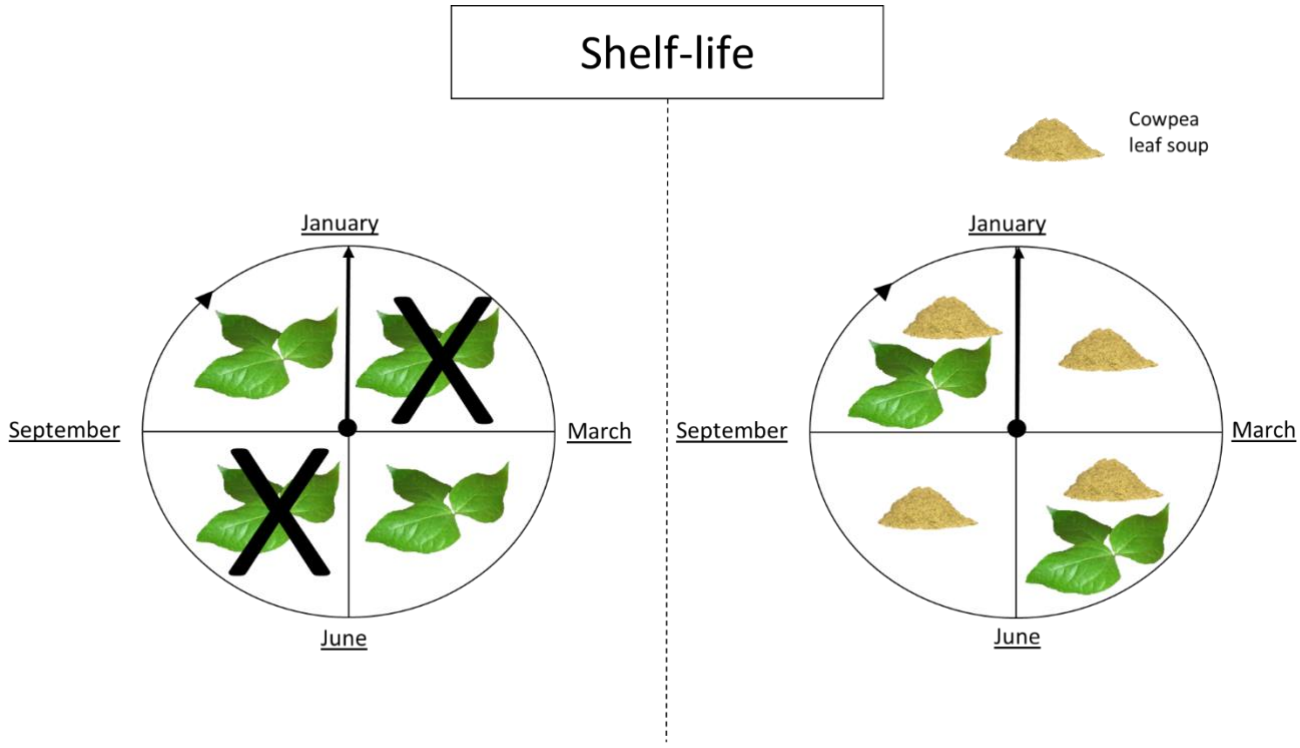
Variable	With information mean (Std.)	Without information mean (Std.)	Difference (p-value)
Sex (Female)	58%	57%	0.772
Age (years)	38.41 (12.47)	37.72 (12.95)	0.285
No. of household members	4.27 (2.16)	4.17 (2.19)	0.421
Education level (1 = none; 2 = primary; 3 = secondary; 4 = tertiary)	2.48 (0.72)	2.52 (0.78)	0.469
Wealth (Index)	0.002 (1)	-0.002 (1)	0.332
Location (urban)	50%	48%	0.551
Sensory perception			
Cowpea leaf soup mix	0.12 (0.91)	-0.13 (1.07)	0.037**
Guava nectar	-0.03 (0.99)	0.03 (1.01)	0.814
Dried cashew apples	-0.04 (0.97)	0.04 (1.03)	0.375
African nightshade relish	-0.03 (1.06)	0.03 (0.93)	0.865
Dried African nightshade	-0.05 (0.96)	0.05 (1.04)	0.334
Jackfruit juice	-0.11 (1.04)	0.11 (0.94)	0.053*
N	482	460	

Note: * $p < 0.1$ and ** $p < 0.05$ according to Mann-Whitney-U-Test

Figure A. 1: Information treatment for the cowpea leaf soup mix (Kenya)

Insufficiency in micronutrients such as vitamin A, vitamin C, or iron has been reported in Kenya. With an insufficient intake of micronutrients, we are more prone to night blindness, tiredness, and infection. Eating a cowpea leaf soup mix can help improve your health because it is a good source of vitamin A, iron, and zinc. Cowpea leaves are even more nutritious than kales which are commonly consumed. While fresh cowpea leaves are only available during harvest season, the cowpea leaf soup mix has a long shelf life. It is available all year-round, independent of the cowpea growing season. This allows you to consume it even when fresh cowpeas are not available. The cowpea leaf soup mix can be stored over several months and will remain safe. Preparing a cowpea soup mix is easy and fast. Once the water boils, the soup is ready within five minutes. No special cooking skills are needed. This saves time.


Nutritional value
Micronutrient deficient
prone to
Blindness
Tiredness
Infection
Cowpea
leaf soup
improve
Eyesight
blood health
Health


Shelf-life
January
September
March
June
Cowpea
leaf soup
January
September
March
June

Convenience

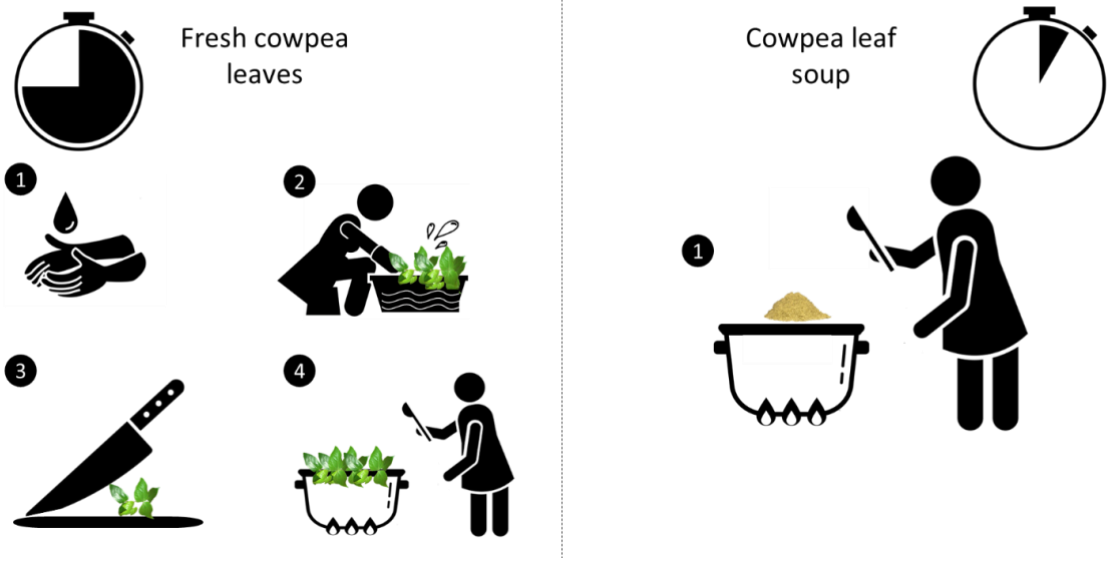


Table A. 2: Descriptive statistics of participants by country and location

	Kenya			Tanzania			Uganda		
	Rural	**Urban**		**Rural**	**Urban**		**Rural**	**Urban**	
Variable	Mean (Std.)	Mean (Std.)	Difference (p-value)	Mean (Std.)	Mean (Std.)	Difference (p-value)	Mean (Std.)	Mean (Std.)	Difference (p-value)
Female	62%	55%	0.195	54%	59%	0.397	67%	48%	0.000***
Age (years)	38.95 (13.7)	34.97 (11.37)	0.021**	40.53 (13.03)	39.22 (14.4)	0.458	38.83 (13.39)	35.45 (11.30)	0.036**
No. of household members	3.97 (2.04)	3.51 (1.84)	0.055*	4.33 (2.04)	4.4 (1.67)	0.545	4.96 (2.82)	4.09 (2.21)	0.006***
Education level (1 = none; 2 = primary; 3 = secondary; 4 = tertiary)	2.60 (0.75)	2.99 (0.82)	0.000***	2.16 (0.62)	2.33 (0.63)	0.017**	2.47 (0.72)	2.54 (0.74)	0.316
Wealth (Index)	-0.25 (1.19)	0.34 (0.51)	0.328	-0.54 (1.31)	0.32 (0.56)	0.000***	-0.03 (1.03)	0.25 (0.69)	0.764
Information (yes)	49%	52%	0.631	51%	53%	0.666	51%	51%	0.889
Sensory perception									
Cowpea leaf soup mix	-0.03 (1.06)	0.03 (0.94)	0.885						
Guava nectar	-0.1 (1.06)	0.11 (0.92)	0.088*						
Dried cashew apples				-0.07 (0.98)	0.08 (1.02)	0.051*			
African nightshade relish				0.03 (0.95)	-0.04 (1.06)	0.662			
Dried African nightshade				-0.07 (1.04)	0.08 (0.95)	0.048**			
Jackfruit juice							0.04 (1.04)	-0.04 (0.95)	0.132
N	149	134		177	156		150	173	

Note: * p < 0.1, ** p < 0.05, and *** p < 0.01 according to Mann-Whitney-U-Test

Table A. 3: Descriptive statistics of participants by country and sex

	Kenya			Tanzania			Uganda		
	Men	**Women**		**Men**	**Women**		**Men**	**Women**	
Variable	Mean (Std.)	Mean (Std.)	Difference (p-value)	Mean (Std.)	Mean (Std.)	Difference (p-value)	Mean (Std.)	Mean (Std.)	Difference (p-value)
Location (urban)	52%	44%	0.195	44%	48%	0.379	64%	45%	0.000***
Age (years)	35.02 (12.54)	38.49 (12.78)	0.013**	40.51 (13.59)	39.47 (12.06)	0.653	35.69 (13.38)	38.04 (11.55)	0.015**
No. of household members	3.41 (1.85)	3.99 (2.01)	0.014**	4.42 (1.98)	4.31 (1.80)	0.490	4.41 (2.74)	4.55 (2.39)	0.183
Education level (1 = none; 2 = primary; 3 = secondary; 4 = tertiary)	3.04 (0.78)	2.60 (0.78)	0.000**	2.32 (0.61)	2.18 (0.64)	0.073*	2.60 (0.71)	2.44 (0.74)	0.044**
Wealth (Index)	0.07 (0.94)	0.00 (1)	0.82	-0.06 (1.06)	-0.21 (1.16)	0.065*	0.17 (0.82)	0.08 (0.92)	0.105
Information (yes)	46%	53%	0.237	54%	50%	0.486	51%	51%	0.908
Sensory perception									
Cowpea leaf soup mix	-0.05 (1.09)-	0.03 (0.93)	0.772						
Guava nectar	0.04 (0.93)	0.03 (1.05)	0.233						
Dried cashew apples				-0.17 (1.15)	0.13 (0.85)	0.035*			
African nightshade relish				-0.05 (1.05)	0.04 (0.96)	0.502			
Dried African nightshade				-0.00 (0.99)	0.00 (1.01)	0.753			
Jackfruit juice							-0.16 (1.04)	0.12 (0.95)	0.005***

Table A. 3: continued

Willingness to pay (US $)									
Cowpea leaf soup mix	1.04 (0.91)	0.79 (0.59)	0.083*						
Guava nectar	1.11 (0.91)	0.88 (0.66)	0.047**						
Dried cashew apples				0.51 (0.42)	0.42 (0.25)	0.332			
African nightshade relish				0.44 (0.33)	0.41 (0.22)	0.964			
Dried African nightshade				0.50 (0.29)	0.51 (0.30)	0.706			
Jackfruit juice							1.59 (0.72)	1.39 (0.07)	0.002***
N	116	167		146	189		140	183	

Note: * p < 0.1, ** p < 0.05, and *** p < 0.01 according to Mann-Whitney-U-Test

Table A. 4: Results of the sensory analysis

	Cowpea leaf soup mix	Guava nectar	Dried cashew apples	African nightshade relish	Dried African nightshade	Jackfruit juice
Color	3.95 ± 1.02^{a}	4.18 ± 0.93^{b}	4.32 ± 0.63^{bc}	4.10 ± 0.66^{ad}	4.33 ± 0.68^{bce}	4.56 ± 0.68^{f}
Aroma	4.15 ± 0.97^{a}	4.35 ± 0.91^{b}	4.29 ± 0.65^{ac}	4.04 ± 0.75^{d}	4.32 ± 0.66^{ace}	4.49 ± 0.76^{bf}
Texture in the mouth	4.15 ± 0.98^{a}	4.41 ± 0.78^{b}	4.32 ± 0.69^{ac}	4.16 ± 0.72^{ad}	4.34 ± 0.68^{ce}	4.53 ± 0.77^{f}
Taste	4.23 ± 1.07^{a}	4.62 ± 0.68^{b}	4.61 ± 0.57^{b}	4.38 ± 0.72^{ad}	4.56 ± 0.69^{bce}	4.72 ± 0.62^{f}
General appearance	4.33 ± 0.86^{a}	4.56 ± 0.71^{b}	4.69 ± 0.54^{c}	4.41 ± 0.70^{ad}	4.63 ± 0.64^{bce}	4.72 ± 0.51^{cef}
N	283	283	332	333	329	323

Note: different letters a, b, c, d, e, f reflects a significant difference in a characteristic between products ($p < 0.05$) according to Kruskal -Wallis and Dunnet-T; scales for all five categories ranged from 1 = dislike it very much to 5 = like it very much

3 Creating economic value for indigenous fruits and vegetables – Marketing insights from six processed products in East Africa[3]

A similar version of this paper is currently under review in International Food and Agribusiness Management Review

Abstract:

The economic potential of indigenous fruits and vegetables (IFVs) in East Africa is neglected. Due to their high perishability large amounts of fresh produce go to waste. Previous studies highlighted the potential of processing IFV to increase their economic value, extend shelf lives, bridge off-season gaps in nutrition supply, and improve livelihoods for rural communities. There is, however, only limited discussion on optimal marketing of processed IFVs, which is a prerequisite for their successful implementation. This study analyzes strategies for producers to optimize pricing, and placement of six different IFVs in Kenya, Tanzania, and Uganda and characterizes potential customers. First, we describe the nutritional value of each product. Second, we analyze producer surplus based on production costs and empirical estimation of consumers' willingness to pay. Fourth, we discuss the benefits and challenges selling to supermarkets and open markets. Finally, we suggest marketing strategies for processed IFVs in East Africa. We find, that processing IFVs can be a great income opportunity for farmers and lower their dependence on seasons. The economic potential, however, depends on the specific product.

Keywords: producer surplus; pricing; placement; small-scale farmers; marketing

[3] This paper is co-authored by Rachel Byarugaba (RB), Noel Dimoso (ND), Marynurce Kazosi (MK), Sam Agaba Kyamanywa (SK), Duke Gekonge Omayio (DO), Joshua Ombaka Owade (JO), Frank Sangija (FS), and Dominic Lemken (DL). JT and DL developed the research idea, JT, RB, ND, MK, SK, DO, JO, and FS collected the data, JT did the data analysis, and wrote the paper. DL commented at all stages of the research and all authors contributed to writing and revising the paper.

3.1 Introduction

African indigenous fruits and vegetables (IFV) can provide many benefits to consumers and producers. For one thing, they are rich in minerals and vitamins essential for human health, such as iron, zinc, and vitamin A (e.g., Omotayo & Aremu, 2020; Owade et al., 2020; Sangija et al., 2021). On the other hand, as they often grow naturally (e.g., Omayio et al., 2020) and are more stress-tolerant than exotic plants to extreme weather conditions such as extended drought periods, they can enhance farmers' resilience and be of excellent farm value (Baldermann et al. 2016). Nevertheless, they have been neglected by national and international researchers and policymakers, causing them to remain below their potential (Hunter et al. 2019).

The undervaluation has several implications for their utilization. Gogo et al. (2018) report that farmers of indigenous vegetables in Kenya lose up to 50% of their produce due to inappropriate harvesting and handling techniques, inadequate postharvest treatment, and preservation methods. Moreover, they are often perceived as poor people's plants (Muhanji et al. 2011). Hence, there is a need to improve their cultivation and reputation and demonstrate their economic potential (Omotayo and Aremu 2020).

Omotayo & Aremu (2020) propose processing to enhance the utilization of indigenous fruits, which would not only help improve year-round access to nutritious food but also create jobs and increase farm households' income. Processing can also help farmers decrease income dependence on seasonality, as has been demonstrated in the baobab value chain (Jäckering, Fischer, and Kehlenbeck 2019). While some modern processing and preservation techniques are costly to implement and difficult to operate (Sangija, Martin, and Matemu 2021), simple processing, such as drying and fermentation, are cost-effective solutions farmers can easily apply, also in rural areas (Sangija, Martin, and Matemu 2021; Sivakumar et al. 2020). However, farmers can only expect additional processing income if the final product is demanded and purchased by customers, and the economic benefits of processing IFV can only be derived if market prices exceed processing expenses.

Therefore, the objective of the present study is to show how the marketing opportunities of IFV can be improved. The target IFVs are currently undervalued as their economic

potential is not being fully understood, as they have received little attention by researchers and policymakers. The included IFV are cowpea leaves and guavas in Kenya (Omayio et al. 2019; Owade et al. 2020a), African nightshade (Sangija, Martin, and Matemu 2021) cashew apples in Tanzania (Dimoso et al. 2020), and jackfruits in Uganda (Balamaze et al. 2019). These crops are mainly consumed during harvest season, which occurs once or twice a year and lasts from two to three months, in fresh form. Little or no processing techniques are applied, causing surplus fruits and vegetables (FV) to spoil (Balamaze et al. 2019; Dimoso et al. 2020; Omayio et al. 2019; Owade et al. 2020b; Sangija, Martin, and Matemu 2021). Hence, farmers are bound to seasons, can expect only small marginal returns, and, due to their short shelf life, have only limited power on market prices (Dinssa et al. 2016).

Therefore, we aim to address three research questions: (i) Can farmers expect additional income from processing IFV, and what price should they ask of consumers? (ii) How do sociodemographic characteristics, nutritious food consumption, and the perception of tradition and processors influence consumers' readiness to pay that price? (iii) What market channels can farmers employ and what challenges and benefits are involved?

This study adds to the existing literature by providing information on the economic benefits farmers can achieve by marketing IFV products. This research has implications for policymakers and food processors. Policymakers will learn about IFV products' economic potential, which will have broader importance on food security, job creation, and rural development. Additionally, the results can provide farmers with a better understanding of the marketing considerations of IFV, thereby possibly providing incentives to enhance their utilization and lower food losses.

The rest of the article is organized as follows. The methods are described in Section 3.2, which includes a description of the products, estimation of producer surplus, and optimal prices based on empirical analysis of demand and estimations of production costs. The findings, as well as benefits and challenges for farmers selling to different markets are described and discussed in Section 3.3. Concluding remarks and policy recommendations are made in Section 3.4. Additional survey information is presented in the appendix 3.5.

3.2 Methods

3.2.1 Products

The products considered in this survey were developed by nutrition and food scientists at University of Nairobi, Kenya (Owade et al., forthcoming, Omayio et al., forthcoming), the Nelson Mandela Institution of Science and Technology in Arusha, Tanzania (Sangija et al., forthcoming, Kazosi et al., forthcoming, Dimoso, Makule, et al., 2020) and the Makerere University in Kampala, Uganda. Although we focus on six individual products, we can find several similarities. Each of the products is high in nutrients, such as vitamin A, iron and zinc, and, thus, providing numerous health benefits, such as improved digestion, cholesterol reduction and protection against infectious diseases (Dimoso et al. 2020; Owade et al. 2020a; Sangija, Martin, and Matemu 2021). Additionally, the products contain antioxidants and phytochemicals that have been shown to have anticancer, anti-inflammatory, and antiaging properties (Correia et al. 2012). Compared to fresh FVs, they have a longer shelf life and, just like the fresh product, can be prepared quickly. Their long shelf life makes them suitable for high-end markets, such as supermarkets, and consumers in urban areas. The products are appropriate for consumption by all age groups, and the most necessary processing techniques are simple and can be adapted by small-scale processors or rural households (Sangija, Martin, and Matemu 2021). Although refrigeration is not required, it can enhance the flavor of the jackfruit juice and guava nectar. Future processing groups will include willing start-ups and youth and women groups with the capacity to process IFVs. The IFV are not yet processed in the respective countries as their economic potential is not sufficiently valued, leading to low adoption of processing and preservation techniques (Omayio et al. 2019; Owade et al. 2020b). The following paragraphs provide additional information about each product, while further information can be found in Table 6.

Cowpea leaf soup mix

Cowpea leaf soup mix is a powdered product developed from the African indigenous vegetable *Vigna unguiculata*. Following precooking during the processing stage, the powder can be prepared in a few minutes, which is time- and energy-saving. The product is best consumed at home and added to known staples of stiff porridge "ugali", chapatti, and rice as a starter recipe. It offers an additional advantage for use in weaning diets.

Guava nectar

The nectar is a whole fruit juice processed from guava fruit pulp (*Psidium Guajava* L.) and blended with moringa leaf extract. The nectars taste sweet and are ready to drink at any time of the day, regardless of one's location, such as home, school, or work. As guavas are currently not processed in Kenya, processors benefit from untapped and cheap local fruits that are likely to result in high-profit margins.

Dried cashew apples

Dried cashew apples are obtained from the ripe cashew (*Anacardium occidentale* L.) apple fruit. The crispy fruit slices are oval-shaped and light brown. The product is ready to be consumed anywhere. Product processing offers great opportunities, as fresh fruits are cheap due to the lack of the current use and, thus, offer good profit margins.

African nightshade relish

African nightshade relish (ANR) is a lactic acid-fermented product made using African nightshade (ANS) (*Solanum villosum* L.). The fermented ANS pickle is further cooked with locally available ingredients, such as onion, cooking oil, and spices, such as garlic, ginger, and pepper, to produce ANR. The crispy greenish product is ready-to-eat. If preferred, it can be warmed up before consumption. The product can be consumed anywhere and can be eaten alone or with side dishes, such as ugali, rice, cooked banana, cassava, sweet potatoes, and yams.

Dried African nightshade

The dried African nightshade product is made from the African leafy vegetable *Solanum villosum* L. The product is edible in the form of a vegetable as an accompaniment to the main dish, similar to the African nightshade relish, and is made for home consumption. The dried product is minimally processed, with carrots adding value; hence, it needs very little preparation before consumption. For preparation, the consumer only needs to fry other ingredients, such as onions and tomatoes, before pouring the dried products and boiling them for two to five minutes.

Jackfruit juice

Yellow–orange sweet nectar is processed from jackfruit (*Artocarpus heterophyllus* L.), a tropical fruit widespread in many parts of Uganda. Processing involves pasteurizing a

mixture of jackfruit arils that have been pureed and blended with water and preservatives. The product is a ready-to-drink shelf-stable nectar that can remain good for up to six months at room temperature or longer under refrigeration. Consumers can enjoy a nutritious drink in a convenient package without having to deal with the bulkiness and sticky latex of the whole jackfruit.

Table 6: Product overview

	Kenya			Tanzania		Uganda
	Cowpea leaf soup mix	**Guava nectar**	**Dried cashew apples**	**African nightshade relish**	**Dried African nightshade**	**Jackfruit juice**
						
Package size	50 g	250 ml	50 g	50 g	50 g	300 ml
Shelf life of fresh produce (approximate days)	1 – 3	3 – 5	1	1 – 3	1 – 3	6
Shelf life of product (months)	5	3 – 5	6	n/A	6	6
Processing	oven-drying	pulping, pasteurization	solar drying	fermentation	oven drying	pasteurization
Place of consumption	home	anywhere	anywhere	home	home	anywhere
Sales place	supermarkets, local markets	supermarkets; retail shops	supermarkets; retail shops; kiosks	supermarkets; kiosks;	supermarkets;	supermarkets; retail shops, kiosks
Sources	Owade et al., forthcoming	Omayio et al., forthcoming	Dimoso, Makule, et al., 2020	Sangija et al., forthcoming	Kazois et al., forthcoming	Agaba et al., forthcoming

3.2.2 Study site and participants

Data were collected in Kenya, Uganda, and Tanzania between October 2019 and February 2020. We sampled a rural and an urban area in each country. The IFVs grow naturally in the selected rural areas. The urban areas were sampled for comparison reasons and because novel foods often disseminate easier in the urban areas first, before spreading to rural sites. Figure 4 shows an overview of all regions studied. In total, we interviewed 1225 participants. On several occasions, the survey was disrupted by sudden weather changes. To ensure validity, we removed these days from the analysis. Some participants were removed from the analysis as they did not finish the survey. After data cleaning, 939 participants remained for further analysis across Kenya (283), Tanzania (333), and Uganda (323). The interviews occurred at open markets. Besides questioning participants about their socio-demographics, shelf life perception, and convenience preferences, they were asked to taste the products and participate in an economic experiment to determine their willingness to pay (WTP). As the products are not yet certified according to countries' legislation, a sampling in higher-end markets was not possible. Within each study region, four to five markets were sampled. Participants in the survey received a small financial reward as a sign of gratitude for their time. The participation award in each country depended on the estimated WTP that was based on similar products sold. Participants had to meet several qualification criteria, such as being 18 years old (Figure A. 2).

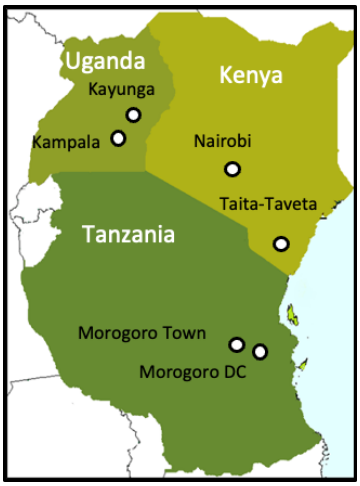


Figure 4: Study site, own adaptation

3.2.3 Determining producer surplus

Willingness to pay

There are several methods for analyzing the value consumers place on a product. In the present study we apply the Becker-DeGroot-Marschak (BDM) auction. The applicability and validity of the mechanism in developing countries have been demonstrated in earlier studies (e.g., De Groote et al., 2011, 2018). The BDM can be conducted individually and is therefore, less time consuming than similar auctions that require a group of bidders. Moreover, the BDM is a binding auction where participants, depending on the outcome of the auction, must buy products using their money. Thus, the procedure is incentive driven and is proposed to lower the risk of overstating the WTP. The course of the auction is described in detail in Figure A. 3.

In Kenya, the BDM was conducted for the guava nectar and the cowpea leaf soup mix; in Tanzania for the African nightshade relish, the dried African nightshade, and the dried cashew apples, and in Uganda for the jackfruit juice. To avoid first order bias, the order of the products was randomized in Kenya and Tanzania. Study participants tasted the products first, before placing their bid. A detailed overview of the examination is presented in Figure A. 2.

Estimating production costs

In the second step, we estimated the production costs for each of the products. The estimations are based on the production within the facilities at our partner universities, namely the University of Nairobi in Kenya, the Nelson Mandela Institution of Science and Technology in Arusha, Tanzania, and the Makerere University in Kampala, Uganda, where the products were originally developed. Hence, we expect slightly lower production costs in the rural areas. We focus on variable costs that vary with production volumes, such as ingredients and estimated energy, water, and labor. Moreover, we assess fixed costs, such as certification. However, we did not include them in the calculation. As processing mechanisms were kept simple to ensure easy adaptability in rural areas, we expect fixed costs to be negligible and not hindering in implementation. Combining

consumers' WTP with the estimated production costs allows calculating the market price (MP) at which farmers can generate the highest surplus.

3.2.4 Regression models

The second research question, namely characterizing participants willing to pay the MP and participants not willing to pay the MP to identify how to best promote the products, is addressed by logistic regression models. We run the analysis for the products that have a sufficiently high number of consumers already willing to pay the MP for the products. Therefore, we regress the WTP for the products on a set of sociodemographic variables including sex, location, age, the number of household members, education level, and wealth, indicators of nutritious food consumption, and the perception of tradition and processors.

$$y_i = \begin{cases} 1 & if\ consumer\ is\ willing\ to\ pay\ the\ MP \\ 0 & if\ consumer\ is\ not\ willing\ to\ pay\ the\ MP \end{cases}$$

In the following equation, the logarithmic transformation of the WTP the MP is displayed:

$$ln\left[\frac{P_i}{1-P_i}\right] = \beta_0 + \beta_1 X_{1i} + \ldots + \beta_k X_{ki} \qquad (2)$$

P is the probability that a consumer is willing to pay the MP, i denotes the i-th observation in the sample, β_0 is the intercept term and β_1, β_2, …, β_k are the coefficients associated with the independent variables X_1, X_2, …, X_k that are to be estimated. We estimate one model per product using Stata 16.

3.2.5 Placement

We address our third research question by discussing two possible placements for the products, namely supermarkets and open markets. Therefore, we assess the existing literature about the benefits and challenges that these marketing channels provide.

3.3 Results and Discussion

3.3.1 Sample description

In general, more female participants completed the survey. Participants' ages range from 18 to 88 years and the number of household members range from 1 to 16. The education

rate is slightly higher in Kenya and Uganda, where approximately 50% had secondary education, whereas approximately 30% receive secondary education in Tanzania.

The mean WTP is 0.42 US$ for the African nightshade relish, 0.51 US$ for the dried African nightshade, 0.56 US$ for the dried cashew apples, 0.89 US$ for the cowpea leaf soup mix, 0.98 US$ for the guava nectar, and 1.48 US$ for the jackfruit juice. All prices were converted into US$, using the exchange rates at the time of the study, and adjusted by the purchasing power parity of the respective country: cowpea leaf soup mix and guava nectar in Kenya (Factor 1.94); dried cashew apples, African nightshade relish, and dried African nightshade in Tanzania (Factor 3.08); and jackfruit juice in Uganda (Factor 3.42) (International Monetary Fund and IMF 2019). Parts of the data set have been used for a consumer demand analysis in a previous study (Tepe et al., forthcoming). A detailed overview of the participants' characteristics is shown in Table A. 5.

Additionally, we inquired about the participants' general food perceptions (Table 7). We find that participants, in general, are concerned about FV scarcity and perishability and prefer foods with a long shelf life. Based on the participants ratings of "strongly disagree" and "agree" to the following statements, more than 70% feel that seasonality causes shortages in FV, that FV perish too quickly, and that it is important that food has a long shelf life. These findings highlight the necessity to introduce processed FVs with prolonged shelf life and are a good entry barrier for farmers to place their products. Moreover, for 43% of the study participants it is important that the food they purchase is from a well-known processor while, for 35%, it is important that the food they purchase follows their tradition. Finally, nearly 70% of the participants feel that it is important that food is easy to prepare, 36% like to take food on the go, and 43% like ready-to-eat foods.

Table 7: Participants' general food perceptions

Item (Variable name)	Obs.	Mean	Std. Dev.	Min	Max
Shelf life[1]					
It is important to me that food has a long shelf life. (Long shelf life)	942	4.14	1.04	1	5
I feel that fruits perish too quickly. (Fruits perish too quickly)	942	3.99	1.05	1	5
I feel that vegetables perish too quickly. (Vegetables perish too quickly)	942	3.92	1.11	1	5
I feel that seasonality causes shortages in fruits. (Seasonality fruits)	942	4.19	1.00	1	5
I feel that seasonality causes shortages in vegetables. (Seasonality vegetables)	942	4.07	1.06	1	5
Familiarity[2]					
How important is it to you that the food you purchase …					
… is in accordance with your tradition? (Tradition)	942	2.24	1.53	1	5
… is from a well-known processor? (Processor)	942	3.04	1.61	1	5
Convenience[1]					
I feel that preparing food takes too much time. (Food preparation too timely)	942	3.00	1.45	1	5
I feel like preparing food is too difficult. (Food preparation too difficult)	942	2.44	1.41	1	5
It is important to me that food is easy to prepare. (Easy to prepare)	942	3.94	1.11	1	5
I like ready to eat foods. (Ready to eat)	942	3.05	1.45	1	5
I like to take food with me on the go. (Food on the go)	942	2.84	1.44	1	5

Items were questioned on a five-point Likert scale ranging from [1] 1=strongly disagree to 5 = strongly agree and [2] 1 = not important at all to 5 = very important

3.3.2 Production costs

We calculated the total production costs for one unit of each product. The prices are consumer prices multiplied by the needed quantity. We found different drivers of the total production costs, depending on the product at hand (Figure 5). For example, whereas labor costs are dominant for the cowpea leaf soup mix, water and energy costs make up more than 50% of the African nightshade relish production costs, and packaging is the primary driver of costs for jackfruit juice. These findings help to define where possible costs reductions could start if necessary.

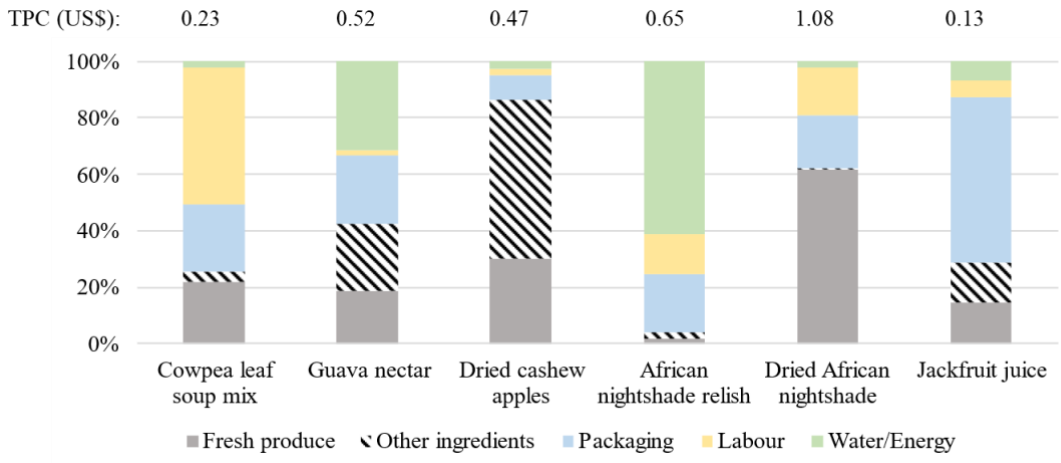


Figure 5: Variable cost compilation, TPC = total production costs per unit: 50 g of the cowpea leaf soup mix, 250 ml of the guava nectar, 50 g of the dried cashew apples, 50 g of the African nightshade relish, 50 g of the dried African nightshade, and 300 ml of the jackfruit juice.

3.3.3 Producer surplus

The optimal market price depends on the profit farmers can expect when selling at a certain price. Using the consumer WTP and the products' production costs, we calculated at which price producers could expect the highest marginal returns from selling their products using Excel (Figure 6). The results suggest different pricing strategies for different products. While they propose a low-pricing strategy for the cowpea leaf soup mix, two MPs for the guava nectar offer similar results. For the jackfruit juice we can see a steady increase in producer surplus up to the MP and a steady decrease afterwards.

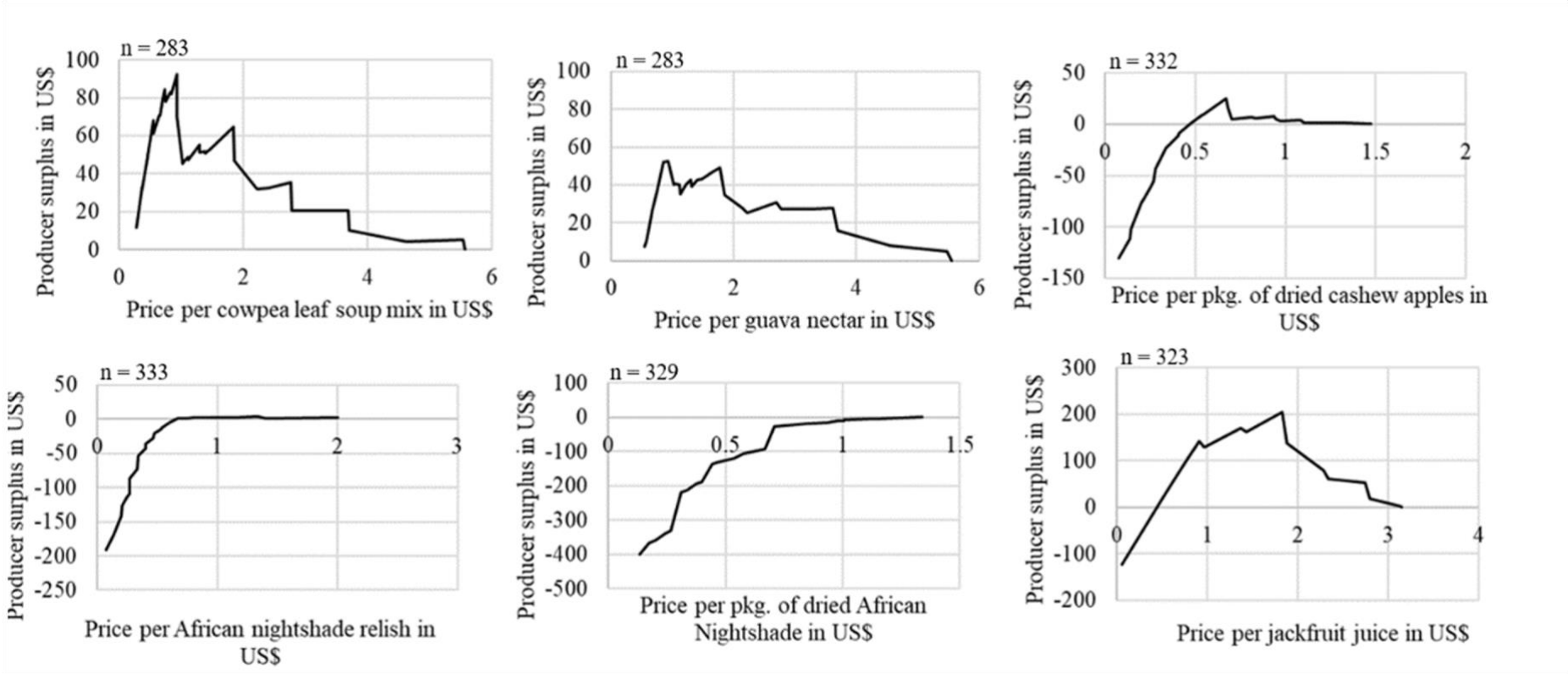


Figure 6: Maximizing producer surplus for each product with Excel. The y-axis shows the producer surplus that can be obtained for the respective price based on the sample

More specifically, we recommend a price of 1.86 US$ for 300 ml of jackfruit juice (Figure 7). Based on our sample size of 323 consumers from whom 147 (45%) were willing to pay the market price, this led to a producer surplus of 208.37 US$. In comparison, 300 g of fresh jackfruit bulbs cost approximately 0.68 US$ (price was adjusted for purchasing power parity). The prices were collected from markets in Kampala, Uganda. Thus, the costs of processed jackfruits are considerably higher. Nevertheless, nearly 50% of our study participants were willing to pay the MP, suggesting that jackfruit juice is demanded among consumers and can provide new income opportunities for farmers.

Our recommended price for the cowpea leaf soup mix and guava nectar is 0.93 US$ for 50 g of soup powder and 250 ml of nectar, respectively. Due to the slightly lower production costs, the cowpea leaf soup mix generates a higher producer surplus of 93 US$ compared to 53 US$ for the guava nectar. Almost 90% of the respondents are willing to pay a price that exceeds production costs, and 45-50% are willing to pay the market price that optimized the producer's surplus. These are welcoming results, implying a reasonable market value of the products. Further, as previous research reported acceptability constraints of processed cowpea leaf, it appears that the product is well chosen and can overcome these constraints (Owade et al. 2020a). Regarding the guava nectars, similar products are already available in Nairobi supermarkets, and some brands process their products locally. The guavas of the already established nectars are not grown in Kenya, allowing the producers to fill a market niche. Prices of already established guava nectars were comparable with the optimal prices we calculated. We found prices for guava nectars ranging from 0.60 US$ to 1.09 US$ (both prices were adjusted for purchasing power parity) in typical supermarkets, such as Naivas, Quickmart, Fairmart, and Selfridges.

We calculated an MP of 0.67 US$ for 50 g of dried cashew apples, which appears to be much lower in comparison. For our sample of 332 participants, the price leads to a producer surplus of 24.71 US$. Still, approximately 40% are willing to pay a price that exceeded the production costs of the dried cashew apples, and approximately 38% are willing to pay the MP. This finding implies that a fair number of people can be motivated to buy dried cashew apples and that there is good potential for farmers to build up a customer base.

Our recommended price for African nightshade relish and dried African nightshade is 1.33 US$, which leads to producer surpluses of 3.42 US$ and 4.89 US$, respectively. The results for both African nightshade products show that 5-10% of the participants are willing to pay a price that exceeds production costs, while a smaller percentage of participants is willing to pay the MP. These findings propose that expenses of the current production technologies and ingredients are high and that financial returns cannot be expected among the studied consumer groups. However, the products are suitable for higher-end markets, where consumers' purchasing power is likely higher. Establishing African nightshade products there first might be an opportunity to overcome the current obstacles.

In conclusion, we find that farmers can generate additional income for most products, although, to distinct extents. Therefore, different pricing strategies are required. We need to note that single farmers will most likely not be able to obtain insights into consumers WTP for specific products. Thus, farmer cooperatives or policy support are required to remedy the situation.

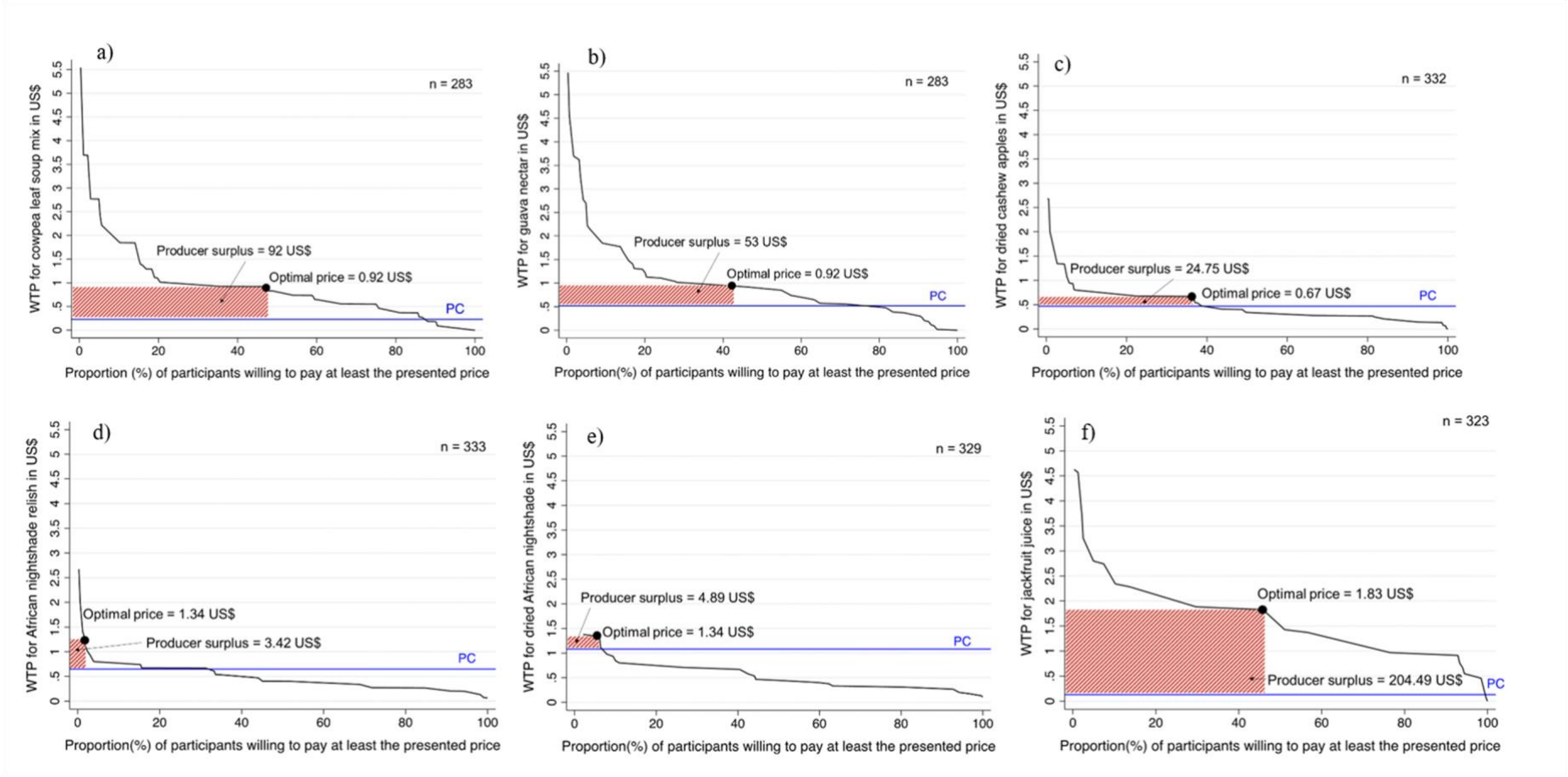


Figure 7: Consumer demand curves and producer surplus for the a) cowpea leaf soup mix, b) guava nectar, c) dried cashew apples, d) African nightshade relish, e) dried African nightshade, and f) jackfruit juice. PC = production costs; all prices and costs were adjusted by the purchasing power of the respective country

3.3.4 Factors influencing consumers' decision to pay the MP

To determine if there are differences between the people willing to pay the MP (buyers) and those who will not buy (nonbuyers), we performed Mann–Whitney-U tests for the cowpea leaf soup mix, guava nectar, dried cashew apples, and jackfruit juice (Table 8). Due to the small number of consumers willing to pay the MPs for the two African nightshade products (Figure 7d & e), they were not included in further analyses. Regarding socio-demographic characteristics, the results show that buyers of the cowpea leaf soup mix, guava nectar, and jackfruit juice are predominantly from urban areas ($p < 0.05$) and were better educated ($p < 0.1$). Moreover, buyers of the jackfruit juice are primarily male ($p = 0.00$), wealthier ($p = 0.02$) and, like buyers of the guava nectar, younger ($p < 0.05$). Moreover, buyers of the cowpea leaf soup mix live in smaller households ($p = 0.08$).

We further analyzed differences in behavior and general food preferences between buyers and non-buyers. All four products show significant differences ($p < 0.1$) between buyers and non-buyers concerning their perception of importance of whether the food they purchased is from a well-known processor, which the non-buyer group prefers. This indicates that raising awareness about the processors could be helpful to drive further acceptance. For the dried cashew apples, we find that the results are reversed. The results concerning the processor follows the findings on the importance that participants placed on the fact that the food they purchase is aligned with their tradition. Further, we find that buyers of jackfruit juice like ready-to-eat food more than non-buyers. Jackfruits are the largest edible tree-born fruit, and their handling is complex, mainly due to their stickiness (Rahman et al. 2016). Thus, processing jackfruit into juice greatly increases its convenience. This aspect is less pronounced for the other products, as eating guava fruit can be just as convenient as drinking fruit nectar. Therefore, it is not surprising that we find differences in liking ready-to-eat foods with jackfruit juice but not for the other products. It also provides insight into promotion strategies for this product. Highlighting the convenience aspect should be further investigated to attract consumers.

Further, non-buyers of the guava nectar are more likely to feel that they already consume nutritious food that was sufficient for good health compared to buyers, suggesting that buyers feel that they do not require additional nutrients. The finding also suggests that the product appeals to consumers who feel that they do not consume nutritious food adequately, which is a welcoming finding from a food security perspective.

Table 8: Participant characteristics by buyers and nonbuyers

Characteristics	*Cowpea leaf soup mix*			*Guava nectar*			*Dried cashew apples*[1]			*Jackfruit juice*		
	Buyer	**Non-Buyer**		**Buyer**	**Non-Buyer**		**Buyer**	**Non-Buyer**		**Buyer**	**Non-Buyer**	
	Mean (Std.)	Mean (Std.)	p	Mean (Std.)	Mean (Std.)	p	Mean (Std.)	Mean (Std.)	p	Mean (Std.)	Mean (Std.)	p
Sociodemographic												
Female (%)	57	61	0.580	58	60	0.770	50	58	0.230	45	66	0.00***
Urban (%)	57	39	0.00***	53	41	0.05**	47	48	1.000	61	47	0.02**
Age (years)	36.93	37.18	0.860	35.40	39.09	0.03**	40.08	39.28	0.380	34.74	38.94	0.00***
	(12.76)	(12.83)		(11.90)	(13.55)		(11.62)	(13.65)		(11.69)	(12.71)	
No. household members	3.63	3.86	0.08*	3.84	3.64	0.970	4.38	4.35	0.980	4.45	4.53	0.550
	(2.11)	(1.82)		(2.15)	(1.71)		(1.94)	(1.87)		(2.64)	(2.47)	
Education level	2.89	2.69	0.06*	2.90	2.64	0.01***	2.26	2.21	0.570	2.57	2.46	0.10*
	(0.82)	(0.79)		(0.82)	(0.77)		(0.56)	(0.68)		(0.73)	(0.72)	
Wealth (Index)	0.12	-0.05	0.310	0.09	-0.05	0.220	-0.05	-0.27	0.250	0.28	-0.01	0.02**
	(0.88)	(1.04)		(0.91)	(1.04)		(1.04)	(1.20)		(0.65)	(1.01)	
Preferences and behavior												
Nutrition[2]	4.48	4.42	0.450	4.38	4.53	0.06*	4.05	4.16	0.180	3.99	3.87	0.170
	(0.78)	(0.78)		(0.79)	(0.76)		(0.77)	(0.81)		(0.88)	(0.86)	
Ready-to-eat food[2]	2.69	2.76	0.660	2.75	2.70	0.940	3.45	3.37	0.560	3.13	2.71	0.01***
	(1.60)	(1.64)		(1.65)	(1.58)		(1.14)	(1.19)		(1.46)	(1.42)	
Tradition[3]	1.53	1.32	0.120	1.52	1.30	0.03**	2.45	1.90	0.00***	2.92	3.23	0.07*
	(1.24)	(1.01)		(1.20)	(1.01)		(1.49)	(1.39)		(1.45)	(1.50)	
Processor[3]	2.64	3.03	0.09*	2.56	3.20	0.01***	3.03	2.24	0.00***	3.51	3.85	0.01***
	(1.80)	(1.91)		(1.79)	(1.91)		(1.55)	(1.44)		(1.18)	(1.14)	
N	134	150		156	128		128	145		148	175	

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ according to MWU; [1] The two groups were unevenly distributed, therefore only 60% of the nonbuyers were randomly chosen.
Nutrition: "The food I eat is nutritious enough for good health"
Ready-to-eat-food: "I like ready to eat foods."
Tradition: "How important is it to you that the food you purchase is in accordance with your tradition?"
Processor: "How important is it to you that the food you purchase is from a well-known processor?"
[2] 5-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree
[3] 5-point Likert scale ranging from 1 = not important at all to 5 = very important

To further analyze characteristics influencing consumers' decision to pay the MP for the products, we ran logit models for the cowpea leaf soup mix, the guava nectar, the dried cashew apples, and the jackfruit juice. As participants' perception of ready-to-eat foods did not show any significant influences, we removed the variable from the logit models. Generally, the results show several consistencies across the products, but there are also product-specific findings (Table A. 6).

For the cowpea leaf soup mix, only being from an urban area significantly increases the likelihood that participants are willing to pay the MP. Participants' likelihood of being willing to pay the MP for the guava nectar significantly increases with an urban area as their location, education level, and the importance of the perception of tradition. Age, consumption of nutritious food, and a combination of location and tradition significantly decrease participants' likelihood of WTP the MP. The negative interaction of location with tradition for the guava nectar implies that urban households perceive the guava nectars as not aligned with their tradition.

For the dried cashew apples, the participants likelihood of the WTP the MP significantly decreases with the number of household members and the importance of tradition. We expect the negative impact of household members due to the small packaging size of the apples used in the survey. Having the apples packaged in different sizes might be appealing to a broader range of consumers and larger families. Similarly, cashew apples are currently mainly consumed directly after harvest and are seldomly found in urban markets, which is why they be a novelty to consumers there.

Regarding the jackfruit juice, we find that, while participants' likelihood of paying the MP decreases with being female, from an urban area, their age, and consuming nutritious food, it increases with wealth and a combination of location and nutrition. Further elaboration shows that, for the jackfruit juice in Uganda, the likelihood of paying the MP is not predominantly shaped by location (rural/urban) but rather a combination of nutrition and location. In this regard, we find that urban consumers who already consume nutritious foods are more likely to pay the MP than rural consumers who do not feel that they already consume nutritious food. One possible explanation might be that the former group has a higher nutrition sensitivity, is more familiar with processed products and, therefore, welcomes the introduction of the juice better.

To sum up, the findings show the importance of considering the existing traditions and food consumption habits within the specific areas where the products are supposed to be sold. The heterogeneous findings about the importance of knowing the processor and that the food is in accordance with one's tradition are highly relevant, as a previous study underlined (Halloran et al. 2015). It further suggests that incorporating aspects of tradition into marketing strategies can help promote the products. Finally, there is a slight tendency for the products to be more successful in urban areas, so it is advisable to begin distribution here.

3.3.5 Placement

Supermarkets

To address our third research question, we discuss the benefits and challenges of selling to different markets. Small- and medium-sized retailers (such as small shops and kiosks inside or outside of wet markets), modern large enterprises, such as supermarkets, and traditional small- and medium-sized businesses such as street vendors, kiosks, and mall restaurants, are all sources of processed foods (Reardon et al. 2021). Thus, various channels reach diverse segments of society.

The developed products fit into the assortment of supermarkets (Demmler, Ecker, and Qaim 2018; Wanyama et al. 2019). Recent literature has highlighted the potential of supermarket value chains to increase the living standards among rural farmers and access to food among both rural and urban populations (Andersson et al. 2015; Qaim 2017). Income gains are also associated with positive indirect effects, such as better dietary quality, including a higher intake of micronutrients, such as vitamin A, iron, and zinc (Chege, Andersson, and Qaim 2015). Nevertheless, participation in supermarket value chains bears additional costs and unforeseen risks. For example, transportation to urban areas is costly, and contracts often do not provide insurance against unexpected product rejection (D. Ochieng, Veettil, and Qaim 2016). Moreover, requirements relating to volume, quality, food safety systems, and consistent year-round supply further impede small-scale farmers' participation (Louw et al. 2008).

Ensuring farmers' competitiveness is essential when including them in supermarket value chains. Ngenoh et al. (2019) proposed access to market information via mobile phones as

an effective tool to keep farmers informed. Nevertheless, it is essential to consider farmers' characteristics when planning and implementing novel business ideas (Ntawuruhunga et al. 2020).

Findings from Kenya show that domestic food processors have difficulty entering high-end markets. Qualification requirements and pricing and payment terms are difficult to overcome (Kamau, Thomsen, and McCormick 2019). Another disadvantage of selling products to markets can be lower home consumption of fresh produce and, thus, lower nutrition intake. For example, evidence from rice farming in Uganda showed that farmers who are more involved in markets consume less of their produce at home, which leads to calorie deficiencies. However, the additional income generated through marketing their products positively affects dietary diversity (Ntakyo and van den Berg 2019).

Open markets

Selling the products via supermarkets will primarily reach higher-income consumers who are already food-secure. Berger and van Helvoirt (2018) highlighted the necessity of policies that ensure the existence of formal and informal markets. The range of healthy food at traditional retailers is vital to reaching poorer consumers (Wanyama et al. 2019). Evidence from West Africa implied that open-air markets and hawkers play an essential role in the food system and that less educated and poorer population groups prefer these channels. Consumers buying from hawkers are primarily looking for convenient ready-to-eat foods and beverages (Meng et al. 2014), while products at open markets are primarily unprocessed and seasonal (Demmler, Ecker, and Qaim 2018). Farmers selling the processed products discussed in this survey at open markets would overcome their dependence on seasons and offer consumers nutritious foods during the off-season, filling a market niche.

Moreover, they do not have to compete with many existing processed products in supermarkets. Additionally, farmers are more likely to operate independently on loose contracts in open markets than in supermarkets, where they are bound to sell a certain quantity. Finally, although selling their products to supermarkets might generate higher income, selling to open markets will lower their risks of failed contracts. Diversification of income is associated with less reliance on other stakeholders that bear unforeseen risks.

3.3.6 Limitations

Before concluding, we need to discuss some limitations of the survey that need to be addressed in the future. First, we did not include consumers from higher-end markets, such as supermarkets but questioned consumers from rural and urban areas; however, we approached them only in open markets. As we have discussed the benefits of farmers' participation in supermarket value chains and the suitability of the products on this market, further research is necessary to confirm the success of this marketing channel. Supermarkets already offer a wide range of processed products, and specific marketing, such as highlighting the local procurement of fresh produce and its nutritional value, might be essential for their success.

Second, we only focused on variable costs. Such costs depend directly on the number of products and are a valid indication when calculating producer surplus. However, especially when implementing novel processing techniques in rural areas, fixed costs, such as machinery costs, are also likely to shape interest in the processing of fresh produce. As fixed costs ultimately depend on unforeseen events, such as the time the machines can be used and the number of products produced by them, including the fixed costs is challenging and was, therefore, not done in the present study.

Finally, there is a need for deeper insights into how to reach consumers most effectively. Our results show diverse results for different products, regarding nutritious food consumption, perception of tradition, and processors. So far, communication strategies to implement novel processed FV remain little studied, requiring further exploration.

3.4 Conclusion and policy implications

To conclude, the results of this research show that the economic benefits of processing IFV can be promising for several but not all developed products. Still, even the promising products require the use of marketing strategies to gain a foothold in the market. We analyzed product, pricing, and placement strategies for possible IFV products. The cowpea leaf soup mix, the guava nectar, the dried cashew apples, and the jackfruit juice reveal great opportunities for farmers to enhance their profit margins and become less dependent on seasons. We also find a tendency that the rural population is less likely to be willing to pay optimal market prices.

However, as the rural population is most vulnerable to food insecurities, especially during lean seasons, policy interventions are required to support the businesses and make the products affordable among poorer population groups. More specifically, we propose the following policy interventions:

First, subsidizing the production of IFV products could be a start, as they could be an opportunity to support farmers' decision to engage with processing in the first place. Research in Uganda demonstrated that one-time agricultural subsidies help raise demand among farmers to adapt to new agricultural technologies (Omotilewa, Ricker-Gilbert, and Ainembabazi 2019).

Second, policymakers must consider consumers, as products will only be successfully implemented if they are demanded. Based on our consumer demand analysis, consumers are highly interested in the products, measured as the number of consumers willing to pay the optimal price. Therefore, policymakers should sensitize consumers about the prospects of processed FVs obtained from local plants for health aspects and rural development. This would not only help increase the demand for products but also improve nutrition among the food-insecure population.

Moreover, the processed products offer more equity for women, who are, for example, involved in African nightshade production (Onyango et al. 2016), reducing their time spent on preparing meals. The current policies are insufficient in protecting health outcomes in the ongoing shift towards more processed foods (Baker et al. 2020). They should switch to supporting foods that offer great nutritional value while supporting local agriculture, boosting income growth in rural areas, and limiting the share of ultra-processed foods.

Third, linking producers to institutions, such as schools, could benefit producers and consumers in the same way. The products are all easy-to-prepare or ready-to-drink and can, thus, be a valuable snack at school. This would also support countries intentions to promote local agriculture and encourage agricultural development. First approaches to link farmers' groups of underutilized plants and schools have started in Kenya (Hunter et al. 2019).

Fourth, we recommend government-supported programs for product development, including processing and sensory analysis test funds. Although not all novel products will

be successful, developing a significant share of profitable products will secure a better use of IFV.

3.5 Appendix

Step 1: Checking participants' eligibility to take part in the survey. Participants had to be

- at least 18 years old
- free of diabetes
- free of any other food sensitivity or allergy
- from the respective country and area
- interested to taste the respective products

Step 2: Informing the participant about his or her right to leave the survey at any time and asking them to sign the consent form

Step 3: Asking the participant to taste the products, one at a time, according to a randomized order

Step 4: Explaining in detail the procedure of the WTP auction (Figure 1)

Figure A. 2: Study protocol

1. The enumerator explains the auction process in detail to the participant, who is encouraged to ask questions.
2. The participant must answer three questions about the procedure correctly to continue. If the answers are not correct, the enumerator will explain the procedure again.
3. After answering the questions correctly, the enumerator shows one product to the participant and asks for his or her WTP.
4. The participant states, for example, 100 KES for the guava nectar.
5. The participant picks a number from a basket with a random distribution of numbers.
6. The stated price is compared to the price picked from the basket.
7. If the picked price is lower or equal to the stated price, the participant must buy the product at the picked price. Otherwise, the participant has no chance of buying the product.

Figure A. 3: Process of the WTP auction

Table A. 5: Descriptive statistics of participants per country

	Country					
	Kenya (n=283)		**Tanzania (n=333)**		**Uganda (n=323)**	
Variable	**Mean (Std.)**	**Range**	**Mean (Std.)**	**Range**	**Mean (Std.)**	**Range**
Female	59%		56%		57%	
Age (years)	37.06 (12.78)	19 - 73	39.92 (12.74)	19 - 76	37.02 (12.41)	18 - 88
No. of household members	3.75 (1.96)	1 - 16	4.36 (1.88)	1 - 12	4.49 (2.55)	1 - 16
Education level (1 = none; 2 = primary; 3 = secondary; 4 = tertiary)	2.79 (0.81)	1 - 4	2.27 (0.63)	1- 4	2.51 (0.73)	1 - 4
Wealth[1] (Index)	0.03 (0.97)	-2.2 - 0.4	-0.14 (1.11)	-2.3 - 0.4	0.12 (0.87)	-2.3 - 0.4
Location (urban)	48%		47%		54%	

[1] The wealth index is based on the World Food Programms' wealth index and includes participants ownership of livestock, land, access to water and sanitation facilities, and types of floor and wall materials (World Food Programme, 2017).

Table A. 6: Influences of participants‘ characteristics on WTP of the market price

	Cowpea leaf soup mix		Guava nectar		Dried cashew apples		Jackfruit juice	
Variables	Coefficient	p	Coefficient	p	Coefficient	p	Coefficient	p
Female	0.057	0.860	0.168	0.624	-0.416	0.311	-0.934	0.000***
	(0.325)		(0.343)		(0.41)		(0.244)	
Urban	1.792	0.028**	5.86	0.001***	1.587	0.192	-2.213	0.032**
	(0.813)		(1.809)		(1.218)		(1.033)	
Age [years]	0.008	0.485	-0.02	0.073*	0.005	0.740	-0.03	0.034**
	(0.012)		(0.011)		(0.014)		(0.014)	
No. household members	-0.064	0.415	0.053	0.354	-0.05	0.067*	0.076	0.115
	(0.079)		(0.058)		(0.027)		(0.048)	
Education level	0.28	0.107	0.361	0.007***	-0.003	0.979	0.048	0.723
	(0.173)		(0.133)		(0.121)		(0.135)	
Wealth [Index]	0.009	0.932	0.011	0.947	0.08	0.139	0.409	0.027**
	(0.111)		(0.162)		(0.054)		(0.185)	
Nutrition	0.35	0.241	-0.649	0.093*	0.36	0.443	-0.726	0.001***
	(0.298)		(0.386)		(0.469)		(0.212)	
Tradition	-0.176	0.773	13.589	0.000***	-0.461	0.033**	-0.087	0.740
	(0.611)		(1.159)		(0.217)		(0.263)	
Processor	-0.266	0.290	-0.426	0.085*	0.687	0.075*	-0.168	0.305
	(0.251)		(0.247)		(0.386)		(0.164)	
Location x Nutrition	-0.117	0.546	0.257	0.361	-0.444	0.167	0.602	0.000***
	(0.193)		(0.282)		(0.321)		(0.144)	
Location x Processor	0.183	0.222	0.248	0.190	-0.253	0.190	0.112	0.483
	(0.149)		(0.19)		(0.193)		(0.16)	
Location x Tradition	0.106	0.758	-6.764	0.000***	0.349	0.036**	-0.042	0.754
	(0.342)		(0.53)		(0.167)		(0.135)	
Observations	283		283		333		323	
Pseudo R^2	0.103		0.158		0.085		0.15	

Standard errors are in parentheses, errors were clustered at market level
**** p<.01, ** p<.05, * p<.1*
The enumerators were included as control variables in all four models

4 Improving the nutritional value of conventional food with underutilized leafy vegetables – Consumers' acceptance of combining porridge with cowpea leaf powder[4]

A similar version of this paper is currently under review in the African Journal of Food Science

Abstract:

Improving the nutritional value of food products as well as dietary diversity to lower micronutrient deficiencies in East Africa is an important step towards reaching the second UN Sustainable Development Goal. At the same time, recent research highlights the importance of processing and preserving highly nutritious African leafy vegetables (ALV) for lowering postharvest losses and bridging off-season gaps. Combining the goals of tackling micronutrient deficiencies and reducing food losses, it seems promising to utilize ALV for enhancing conventional food items that are already well accepted in consumer diets but low in nutritional value. The study presented in this paper analyzes consumer demand for maize and millet porridges combined with cowpea leaf powder (CLP) in Kayunga, Uganda. The study relies on combining sensory analysis with a binding Becker-DeGroot-Marschak auction to analyze consumer demand. Results show that consumer acceptance of CLP-enhanced porridges is predominantly shaped by sensory perception ($p < 0.05$). The effect of providing additional nutrition information depends on the type of porridge ($p < 0.1$). Although adding CLP lowers consumers' sensory appreciation, the study still identifies a reasonably large group of consumers, nearly 50% of the participants, who value CLP-enhanced porridges as much as plain ones. This justifies the conclusion that adding CLP is not without risks but is accepted among many consumers and can thus help to promote the consumption of locally available plants.

Keywords: African leafy vegetables, Uganda, willingness to pay, sensory analysis, porridge

[4] This paper is co-authored by Dominic Lemken (DL). JT and DL developed the research idea, JT collected the data, analyzed the data, and wrote the paper. DL commented at all stages of the research and contributed to writing and revising the paper.

4.1 Introduction

Micronutrient deficiencies in East Africa remain worrisome. More than 30% of the population suffers from an insufficient intake of vitamins and minerals (FAO 2020). Recently, researchers worldwide have acknowledged the importance of micronutrient supply, suggesting the relevance of dietary quality instead of plain caloric intake (Miller et al. 2020). Inadequate dietary quality is among the primary causes of a wide number of health issues ranging from cardiovascular diseases to diabetes and death. Poor dietary quality frequently corresponds with low intake of fruits and vegetables, which is among the leading dietary risk factor (GBD 2017 Diet Collaborators 2019). Significant challenges for dietary quality, especially in the form of adequate dietary diversity, often arise due to insufficient accessibility that disproportionately affect less-developed parts of the world (FAO 2020).

Furthermore, the globally recognized nutrition transition caused diets to shift toward processed foods (Reardon et al. 2021). Since processed food products are often rich in sugar and salt and low in nutrients (Reardon et al. 2021), this shift has induced severe health challenges such as obesity.

Against this backdrop, research needs to highlight pathways for product development towards more nutrient-rich food items that consumers can add to their diets, thereby increasing both the nutritional value of foods consumed and the diversity of their diets. In order to achieve these goals, the relevant food items need to be accessible and affordable and feature the main qualities consumers desire, such as quick and easy preparation. Above all, the food items must have attractive sensory characteristics, as they are an important pre-condition for consumers acceptance (Boateng et al. 2019). This is why it is especially promising to create nutrient-rich food items by enhancing conventional products with more nutrient rich components.

The research presented in this paper reflects this approach. It addresses both nutritional quality and dietary diversity, and analyzes the potential of enhancing consumers' diets through newly developed food items based on enhancement with locally available African Leafy Vegetables (ALV).

So far, hundreds of ALV grown throughout Africa have gained little attention, despite their excellent nutritional value (Aworh 2018). Recent literature, however, has highlighted the potential of ALV in addressing micronutrient deficiencies (Maseko et al.

2019). Ochieng et al. (2018) have found that increases in promotion and demand of ALV in a given community increase dietary diversity for women and children under the age of five years. What is more, ALV are valued for their better resistance to pests, diseases, and harsh weather conditions and are often the cheapest source of essential vitamins and minerals, as compared to exotic crops (Aworh 2018; Bua and Onang 2017).

It is mostly the lack of awareness of health benefits, lack of knowledge of preparation techniques, and off-season gaps that impede sufficient utilization (Bua and Onang 2017). Short shelf lives of only up to two days constitute additional challenges, leading to farmers experiencing losses between 10 and 50% of their harvest (Gogo et al. 2018). This aspect, however, makes the approach of enhancing conventional food items with ALV components appear even more promising. Such enhancement, contrary to direct marketing of recently harvested ALV, would imply the use of ALV components in more durable conditions (e.g., dried or pulverized). Thus, the utilization of locally available ALV in conventional food products would not only improve the nutritional value of the food items consumed, but also would help reduce postharvest losses. Yet, evidence of consumers' perception of and preferences for conventional products enhanced with ALV in East Africa is still scarce.

Barugahara et al. (2015), however, found that fermented millet porridge combined with Moringa oleifera leaves (part of the ALV family) was accepted among children and mothers in Western Uganda and could be part of a solution of tackling malnutrition. In addition, research on attitudes towards healthy foods in similar contexts supports this optimistic claim. De Groote et al. (2020) identified a potential market for improved cereal products in Kenya and Wanyama et al. (2019) found that poor consumers might welcome foods that are micronutrient-fortified or include new types of nutritious ingredients.

Contributing towards closing the research gap on consumers' perception of and preferences for conventional products enhanced with ALV in East Africa, the present study analyzes consumer demand for traditional porridges combined with ALV component of cowpea leaf powder (CLP). The motivation of this study is to test whether combining soft porridge with cowpea leaves could be a practical approach to introducing nutrition-rich vegetables in East African diets, thereby tackling malnutrition by addressing micronutrient deficiencies. The choice of CLP-enhanced porridge builds on two main reasons. First, porridge is an affordable food frequently consumed by the vast

majority of the Ugandan rural population. Its preparation is quick and easy. At the same time, porridges are often solely made out of maize or millet, and lack minerals and vitamins (Ndagire et al. 2015). Second, cowpea leaves provide great nutritional value, and are widely available throughout Uganda (Okonya and Maass 2014). They are rich in minerals and vitamins, and can provide the recommended daily intake of many health essential nutrients, such as iron, calcium, phosphorus, and magnesium (Enyiukwu, Amadioha, and Ononuju 2018). Nevertheless, cowpea leaves are being underutilized, with seasonality and inadequate postharvest handling techniques being among the major challenges. Evidence from Kenya shows that while cowpea leaves are consumed during the season in which cowpeas are produced, consumption declines during the off-season (Owade et al. 2020b). This highlights the importance of preserving cowpea leaves adequately to bridge off-season gaps.

The objectives of the study are: (1) to assess consumers' demand for maize and millet porridges enhanced with CLP relative to plain porridges using willingness to pay (WTP) auction and sensory perception; and (2) to identify factors influencing consumers' acceptance.

The rest of the paper is organized as follows. Section 4.2 describes the conceptual framework. Section 4.3 describes the methods applied, namely sensory testing and the Becker-DeGroot-Marschak auction. Section 4.4 presents the survey's major findings, Section 4.5 offers a discussion, and Section 4.6 concludes.

4.2 Conceptual Framework

At the outset, we want to consider how porridges enhanced with CLP align to food preferences among the Ugandan rural population in general. Uganda is in an early stage of a dietary transition that will probably result in health implications (Auma et al. 2019). As in other East African rural communities, about 43% of the food consumed is purchased, with processed and ultra-processed foods making up 70% of all purchases (Reardon et al. 2021). Minimally processed foods such as flour, dried fish, or packaged milk are foods with only a little modification, such as cleaning, drying, or grinding. Ultra-processed foods such as canned sodas or cookies are highly processed products with added salt, sugar, or oil (Reardon et al. 2021). Maize and millet porridges are ultra-processed foods with low nutritional value beyond calories.

A study on dietary patterns in rural Uganda found that the consumption of processed diets is among the two major dietary habits of middle aged (39 ± 13 years) men and women. This includes high consumption of salad dressing, cold cuts, and sweets. A closer look at food groups being consumed shows mean daily servings of cereals, starchy roots, and plantains are highest (Holmes et al. 2018). Kiguli et al. (2019) found that consumers' food choices in rural Eastern Uganda are predominantly based on availability and local accessibility. There was a particular lack of food diversity during the dry season, and people depended on a few staple foods, such as maize flour, daily. Moreover, a study on pre-cooked beans shows that consumers value nutritious products that are quick to prepare (Aseete et al. 2018).

Combining conventional porridges with CLP fits into the current demand for more processed and nutritious foods. Adding CLP is an option to increase dietary diversity during the off-season.

4.3 Methods

4.3.1 Study site and participants

The survey aims to analyze rural consumers' demand for porridge combined with locally available cowpea leaves. The cowpea leaves were dried and ground, and thus minimally processed. We obtained research permission and ethical clearance from the Makerere University School of Health Sciences' Institutional Review Board Uganda and the Uganda National Council for Science and Technology. The survey was conducted in the Kayunga district of Uganda from February to March 2020. The Kayunga district is a rural area that lies in the North Central part of the country. The prevalence of anemia is around 31% for women and 14% for men, with about 30% of women and 12% of men being overweight or obese (Uganda Bureau of Statistics 2018).

Dietary diversity is lower among rural women than men. Their diet comprises of high fat intake along traditional dietary patterns (Auma et al., 2019). Due to their relatively high prevalence of anemia and lower dietary diversity, and because they are often responsible for food preparation, our main interest was women. However, since food is traditionally prepared for the whole family, we did not completely exclude men from the survey. Cowpea leaves are typical in the area of the study site and are predominantly grown on a small scale.

We targeted participants at point-of-purchase at open markets in Kayunga Town, Busaana, Kangulumira, and Nazigo that were open on different weekdays. A pilot study was conducted at a different market in the same location to test the setup of the survey. As the markets were some kilometers apart (> 20 km), it is unlikely that the same participant visited different markets and got selected twice. Participants were screened for the following characteristics to participate in the survey: They had to be at least 18 years old, free of diabetes and food sensitivities, responsible for food purchasing decisions in the household, and interested in testing the target products. Approaching participants at open markets allowed us to question many of them easily. We avoided conducting the same study more than once per market. This allowed us to ensure that participants were not interviewed twice and were thus not already informed about the products by friends or family. We used convenience sampling that included if participants had time to take place in the survey. Participants were approached when leaving the market. If they did not meet the qualification criteria the next person leaving the market was approached. Approximately 30 participants were questioned per market. The questioning per participant, including the sensory analysis and WTP auction took about 20 minutes. Thus, we spent five to six hours at each market. In total, 126 people participated in the survey. Due to incomplete questionnaires, we excluded 24 participants from further analysis. Participants agreeing to participate in the survey were informed about their right to leave the survey at any time, asked to give their written consent, and were paid 2000 Ugandan shillings (UGX) (3736 UGX = 1 U.S. dollar at the time of the survey) as an expression of our gratitude for their time and to ensure they had the financial means to participate in the WTP experiment.

4.3.2 Products

We asked each participant to taste four different porridges: millet porridge, millet porridge combined with CLP, maize porridge, and maize porridge combined with CLP (Figure 8). The CLP made up 20% of both mixed porridge types, respectively. The rate was defined after running pre-tests on consumer acceptance of different ratios. The products were developed by nutrition specialists of Makerere University in Kampala, Uganda. Owing to the nutrients found in the CLP namely zinc, vitamin A and iron their consumption is associated with improved satiety, good immunity, proper digestion, and proper eyesight. The porridges were prepared in traditional way each morning by experienced cooks from our team. Specifically, 60 g of each porridge were mixed with

150 ml cold water. 300 ml boiling water were added to the two millet porridges and 400 ml boiling water were added to the two maize porridges. The two millet porridges were boiled for two to three minutes, and the two maize porridges were boiled for 30 minutes. As porridge is preferred sweet in the area, 25 g of sugar were added to each mixture. To keep the porridges warm for consumption, they were stored in thermo flasks.

Figure 8: Four different porridges. Millet porridge (O), Millet porridge mixed with CLP (⬠), Maize porridge (Δ), Maize porridge mixed with CLP (□)

4.3.3 Sensory analysis

Tents were used to conduct the survey. This allowed us to shield survey participants and gave them the opportunity to sit down and taste the products in quiet. Each participant was questioned by two enumerators to ensure double-blind testing. The first enumerator asked sociodemographic questions and conducted the sensory analysis. Survey participants received approximately 10 g of each cooked porridge in plastic cups. The amount equaled about three normal mouthfuls of the product, which was presumed to be sufficient to rate the sensory attributes. As we labeled each porridge with either a triangle, circle, square, or pentagon, neither the enumerator nor the participant knew which porridge was inside which cup. The order was randomized to avoid first-sample bias. Participants were asked to rate one porridge at a time. They were not allowed to go back and re-taste samples. Sensory characteristics considered included color, aroma, texture in the mouth, taste, and general appearance. Participants were asked to rate each attribute on a five-point Likert scale ranging from 1 = dislike it very much, 2 = dislike it, 3 = neither like nor dislike it, 4 = like it, 5 = like it very much. The five-point Likert scale has been used in previous studies and was demonstrated to be understandable among less educated consumers (De Groote et al. 2018). The answers were immediately entered onto electronic tablets by the enumerators. Participants were asked to rinse their mouths with water after consuming each product.

4.3.4 Willingness to pay

After finishing the sensory analysis, a second enumerator conducted the WTP using Becker-DeGroot-Marschak (BDM) auction. The BDM is non-theoretical, can be performed individually, and can be implemented at open markets. It has already been applied in several studies assessing consumers' WTP in Africa, and has been easily understood by less-educated participants (e.g, De Groote et al., 2018, 2020). The four porridges were shown to the participant in dried form, packaged in transparent plastic bags. Each bag contained 60 g of the dry porridge powder. The porridges were presented in the same randomized order and labeled with the same symbols as in the sensory analysis. The order differed among the participants. The participants were asked to state their WTP for each of the products. The enumerator wrote down their statements. To prevent participants from having to buy all four products, the statement for one product only was randomly chosen as binding. Each participant then drew a number from a basket, which was compared to the price stated for the binding product. If the drawn number was below or equal to the WTP indicated by the participant, they had to buy the product at the random price using their own money. If the randomly drawn number was higher than the stated WTP, the participant had no chance to buy the product. The random distribution ranged around the expected WTP for one porridge, thus from 100 to 1000.

The procedure was described to the participants in detail, and follow-up questions had to be answered correctly. The enumerator informed every second participant about the ingredients of the porridges and their nutritional benefits. While the explanation of the plain porridges contained information about their bodybuilding and energy benefits, the explanation of the porridges combined with CLP contained further information about their contributions to good immunity, proper digestion, and proper eyesight. We assumed there are no systematic differences between the two groups, although we found tendencies in the color perception (Table A. 7).

After finishing the WTP experiment, participants were questioned on their general consumption and shopping behavior.

4.3.5 Statistical model

We applied structural equation modeling (SEM) using Stata to determine linkages between participant characteristics and their WTP, using maximum likelihood estimation. SEM connects linear regression and factor analysis and, in general, analyzes variance-

covariance structures (Aichholzer 2017). SEM allowed us to use the response variable of one regression as a predictor in another regression.

Figure 9 shows an exemplary SEM. Rectangles represent observed variables, and circles containing ∈ represent error terms. Arrows indicate hypothesized direct effect on endogenous variables. The SEM shows the sum of all assumed structural equations:

$$y_1 = \alpha_1 + \gamma_{11} x_1 + \varepsilon_1 \quad (3)$$

$$y_2 = \alpha_2 + \gamma_{21} x_1 + \beta_{12} y_1 + \varepsilon_1 \quad (4)$$

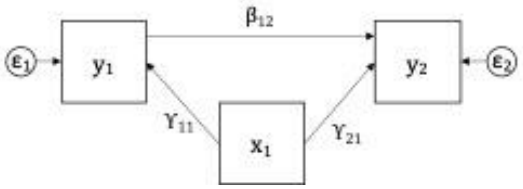


Figure 9: Exemplary SEM

4.3.6 Variable selection

We estimated one SEM for the millet porridges and one for the maize porridges. Figure 10 shows the model for the maize porridge. Within both SEMs, we ran two equations, one for the plain porridge and one for the porridge combined with CLP. The plain porridge was also included as a predictor in the regression for the combined porridge. One directly observed variable was used as a predictor, namely whether the participant received additional *information* (binary) about the products. Additionally, we added *frequency of cowpea leaf consumption* in the regressions of the combined porridges. Frequency of cowpea leaf consumption categorically ranged from 0 = never, 1 = 1 to 3 times per month, 2 = 1 to 3 times per week (regularly), 3 = 4 to 7 times per week (frequently).

Besides directly observable variables, *nutrition awareness* and the *sensory perception* of each porridge were added as factor variables. To obtain the factors, we ran a principal component factor analysis with varimax rotation. We found that the sensory characteristics of each porridge loaded on one factor, respectively (Table 9). Additionally, we found that six nutrition statements loaded on one factor (Table 10). The sampling

adequacy was determined via Bartlett's test and the Kaiser-Meyer-Olkin (KMO) criterion. The internal consistency was determined via Cronbach's-α. KMO values above 0.6 and Cronbach's-α values above 0.5 were considered acceptable. The Cronbach's-α for the sensory characteristic's factors ranged between 0.74 and 0.88, with KMO values ranging between 0.77 and 0.84. The Cronbach's-α for the nutrition awareness factor was 0.75 and the KMO 0.78. The enumerator effect was included as a control variable. The error term was robust and clustered at market level.

To determine the robustness of the model we reran the calculation including age in years, being female, and education in years.

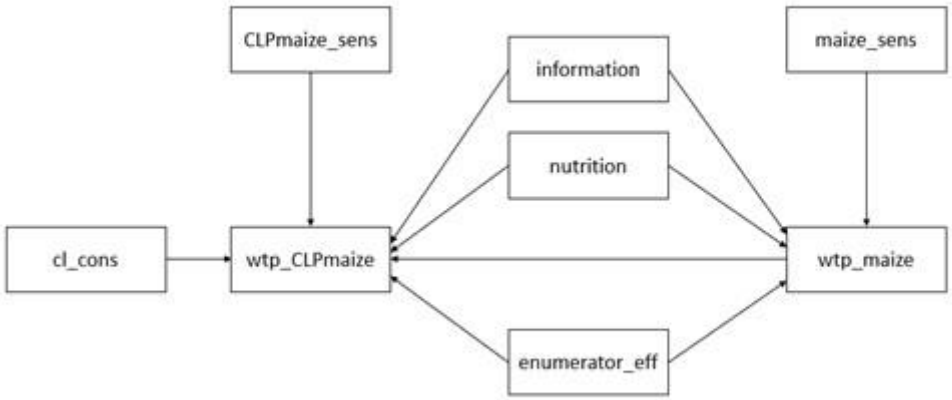


Figure 10: SEM for WTP for maize porridge and maize porridge with CLP. cl_cons = frequency of cowpea leaf consumption, sens=sensory perception (factor)

Table 9: Results of the factor analysis on sensory perception of the porridges

	Factor loading			
Characteristic[1]	Millet	CLP_millet	Maize	CLP_maize
Color	0.70	0.71	0.73	0.59
Aroma	0.71	0.84	0.74	0.81
Texture in the mouth	0.62	0.83	0.85	0.81
Taste	0.74	0.86	0.83	0.84
General appearance	0.78	0.86	0.83	0.87
Cronbach's-α	0.74	0.88	0.85	0.84
KMO	0.77	0.84	0.78	0.83

[1] 5-point Likert scale ranging from 1 = dislike it very much to 5 = like it very much

Table 10: Results of the factor analysis on dietary behavior

Nutrition awareness[1]	Factor loading
I am eating enough vegetables for good health.	0.54
I compare labels to select the most nutritious food.	0.80
I usually look for health information when I buy food products.	0.62
When at the market I look for food that supports the prevention of diseases.	0.65
When at the market I look for food that supports a strong immune system.	0.79
When at the market I look for food that supports good eyesight.	0.61
Cronbach's-α	0.75
KMO	0.78

[1] 5-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree

4.4 Results

4.4.1 Participant characteristics

Participants had an average age of about 37 years, were mainly female (72%), and received 7.5 years of formal education (Table 11). On average, participants lived in households comprising of five people. 26% of the participants were married. 67% of the participants consumed millet porridge as their main porridge, while the remaining 33% consumed maize porridge as their main porridge. 79% of the participants had children between 6 and 59 months. Most participants consumed porridge frequently (4 to 7 times per week) or regularly (1 to 3 times per week). Half of the participants reported that they consumed cowpea leaves at least 1 to 3 times per week.

Concerning nutrition awareness, we found a tendency that participants tended to agree with the statements we presented, with mean values above 3. The statements “I am eating enough vegetables for good health” and “When at the market I look for food that supports a strong immune system” received the highest agreement with mean values of 3.96 and 3.92, respectively.

Table 11: Participant characteristics and consumption frequencies

Characteristics	Mean	SD	Min.	Max.
Sociodemographic				
Age (years)	36.76	12.73	18	80
No. household members	5.14	2.44	1	14
Years in formal education	7.51	3.36	1	17
Female	72%			
Married	26%			
Millet main porridge consumed	67%			
Children 6 to 59 month	79%			
Porridge consumption				
4 to 7 times per week	60%			
1 to 3 times per week	36%			
1 to 3 times per month	4%			
Cowpea leaf consumption				
4 to 7 times per week	4%			
1 to 3 times per week	50%			
1 to 3 times per month	18%			
Less than once per month/never	28%			
Nutrition awareness[1]				
I am eating enough vegetables for good health.	3.96	1.03	1	5
I compare labels to select the most nutritious food.	3.28	1.15	1	5
I usually look for health information when I buy food products.	3.36	0.97	1	5
When at the market I look for food that supports the prevention of diseases.	3.76	1.03	1	5
When at the market I look for food that supports a strong immune system.	3.92	0.86	1	5
When at the market I look for food that supports good eyesight.	3.72	1.02	1	5
N	102			

[1] 5-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree

4.4.2 Sensory analysis and WTP

The mean sensory scores were highest for the plain millet porridge in all five characteristics (Table 12). These differences were found to be statistically significant, except for the taste in maize. Sensory scores for the porridges combined with CLP received statistically significantly lower scores than their plain porridge counterpart in all characteristics. Millet porridge combined with CLP received statistically significantly higher scores than maize porridge combined with CLP for color and texture in the mouth. Although on average the plain porridges were rated higher than the combined porridges, we found that 40 to 50% of the participants rated the combined porridges at least as high as the plain ones.

The mean WTP was highest for plain millet porridge (0.26 US$). This price was significantly higher than the average for the remaining porridges. About 50% of the participants were willing to pay an equally high price for the combined porridges compared to the plain porridges. The distribution of WTP is shown in Figure A. 4.

Table 12: Results of the sensory analysis

Characteristic	CLP_Millet	Millet	% CLP_Millet >= Millet	CLP_Maize	Maize	% CLP_Maize >= Maize
	Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)	
Color	3.26[a]	4.26[b]	42	2.62[c]	3.75[d]	45
	(1.34)	(1.09)		(1.39)	(1.33)	
Aroma	2.93[a]	3.99[b]	41	2.85[ac]	3.72[bd]	51
	(1.31)	(1.13)		(1.40)	(1.32)	
Texture in the mouth	3.60[a]	4.37[b]	46	3.25[c]	3.95[d]	40
	(1.30)	(0.87)		(1.35)	(1.39)	
Taste	3.22[a]	4.27[b]	35	3.20[ac]	4.18[bd]	50
	(1.45)	(1.08)		(1.39)	(1.09)	
General appearance	3.57[a]	4.55[b]	46	3.37[ac]	4.26[d]	46
	(1.19)	(0.67)		(1.27)	(0.99)	
WTP (US$)	0.22[a]	0.26[b]	48	0.22[ac]	0.23[abcd]	52
	(0.18)	(0.19)		(0.21)	(0.19)	
N	102	102		102	102	

Note: The letters a,b,c,d reflect significant differences ($p < 0.05$) in a characteristic between the porridges according to Kruskal-Wallis and Duncan-T; % CLP_Millet >= Millet = Percentage of participants who rated the porridge combined with CLP at least as high as the plain porridge.

4.4.3 Structural equation model

Table 13 presents the results obtained from SEM for the millet and maize porridges. Information about the ingredients and health benefits significantly increased participants' WTP for the plain and combined millet porridge. Additionally, participants with a higher nutritional awareness were willing to pay more for the plain millet porridge. Moreover, a higher WTP for both combined porridges is in line with a higher sensory perception of the products and a higher frequency of cowpea leaf consumption.

To check for the robustness of the findings, we reran the model with control variables. These variables included age, being female, and education (Table A. 8). We observed the same trends.

Based on these findings, we took a deeper look into differences in sociodemographic and sensory perception. We compared these factors between a) participants who were willing to pay a price for the combined porridges that was at least as high as the price for the respective plain porridge (liker) and b) the ones who were not willing to pay that price (non-liker) (Table 14). In total, 48 participants were likers. The frequency of cowpea leaf consumption was significantly higher among this group, and nearly everyone had a child between 6 and 59 months. On average, likers rated all sensory characteristics of both combined porridges higher than non-likers did. This effect was found to be statistically significant for all sensory attributes, except the aroma of the millet combined with CLP.

Table 13: Results of the structural equation model

N = 102	Millet			Maize		
	Coef.	SE[a]	p	Coef.	SE[a]	p
Information	0.183	0.104	0.080*	0.146	0.136	0.281
Nutrition (factor)	0.294	0.086	0.001***	-0.008	0.092	0.932
Sensory perception (factor)	-0.119	0.084	0.155	0.132	0.101	0.192
	Millet porridge combined with CLP			**Maize porridge combined with CLP**		
	Coef.	SE[a]	p	Coef.	SE[a]	p
wtp_millet	0.572	0.066	0.000***			
wtp_maize				0.434	0.246	0.078*
Freq. cowpea leaf cons.	0.121	0.012	0.000***	0.040	0.012	0.001***
Information	0.094	0.057	0.099*	0.153	0.117	0.191
Nutrition (factor)	-0.083	0.059	0.156	0.090	0.117	0.441
Sensory perception (factor)	0.267	0.055	0.000***	0.237	0.023	0.000***

[a] Standard errors are robust and clustered at market level, coefficients are standardized

* reflects significance at 10%,

** reflects significance at 5%, *** reflects significance at 1%

Table 14: Participants characteristics by WTP

	Liker	**non-liker**	
Characteristics	Mean (SD)	Mean (SD)	p
Female	73%	70%	0.950
No. household members	5.52 (2.56)	4.80 (2.29)	0.140
Years in formal education	7.83 (3.89)	7.22 (2.81)	0.650
Children 6 to 59 months (binary)	90%	70%	0.03**
Frequency cowpea leaf consumption	4.58 (2.07)	3.56 (2.18)	0.01***
Frequency porridge consumption	6.94 (1.19)	6.98 (1.28)	0.710
Nutrition awareness (factor)	-0.1 (1)	0.09 (0.1)	0.33
Color CLP_mill	2.92 (1.49)	2.35 (1.26)	0.06*
Aroma CLP_mill	3.08 (1.35)	2.65 (1.42)	0.110
Texture CLP_mill	3.48 (1.27)	2.94 (1.46)	0.06*
Taste CLP_mill	3.56 (1.22)	2.98 (1.41)	0.04**
General appearance CLP_mill	3.69 (1.03)	3.09 (1.40)	0.03**
Color CLP_maize	3.54 (1.24)	3.02 (1.39)	0.05**
Aroma CLP_maize	3.33 (1.24)	2.57 (1.28)	0.00***
Texture CLP_maize	3.62 (1.38)	2.85 (1.43)	0.01***
Taste CLP_maize	3.94 (1.14)	3.30 (1.37)	0.02**
General appearance CLP_maize	3.90 (1.06)	3.28 (1.23)	0.01***
N	48	54	

* Reflects significance at 10%, ** reflects significance at 5%, *** reflects significance at 1%. Likers are participants who were willing to pay at least as much for porridges combined with CLP as for the plain porridges

4.4.4 Discussion

Our study is based on combining traditional porridges with nutrient-rich CLP as a channel to incorporate nutritious vegetables into local diets. Regular consumption of CLP-enhanced porridges will improve dietary diversity as they are rich in micronutrients such as iron, zinc, and vitamin A. Additionally, processing cowpea leaves into more durable powder can reduce postharvest losses and bridge off-season gaps. Enhancing traditional porridges with CLP thus appears to be a promising option, under the condition the product meets consumer demand.

First of all, our results confirmed the assumption that porridge is a highly suitable product for enhancing nutrition among the rural population, since porridge is frequently consumed by the survey participants (4 to 7 times per week). Focusing on the core of our research question, our results showed that almost half of the participants valued the CLP-enhanced porridges at least as high as the traditional, non-enhanced ones. For this group, the enhanced product can provide an easily accessible and cheap source of important nutrients.

However, we also found that combining traditional porridges with CLP lowers sensory appreciation. This leads to the conclusion that the combined porridges will not replace the plain ones but might have a chance as an alternative product on the market. The SEM revealed that sensory perception is an essential factor shaping consumers' WTP for CLP-enhanced porridges. The effect sizes of sensory perception in both combined models were higher than of the remaining three variables.

The importance of sensory perception was consistent with research on nutritionally enhanced food via biofortification such as quality protein maize. Similar to our findings, De Groote et al. (2014) found that sensory characteristics are among the main drivers of consumers' WTP. Resonating with these findings, another experiment conducted by Wanyama et al. (2019) suggested that ingredients with only minor effects on taste and appearance are seen more positively than ingredients that may change food products more notably.

Since consumption of (and thus familiarity with) nutritious and locally available cowpea leaves was low (less than once per week) among most study participants, promoting their utilization constitutes a challenge, but at the same time, it can potentially open a group of potential consumers for the enhanced product. We presume that increasing familiarity

with cowpea leaves and African leavy vegetables in general will increase the chance of success for the combined porridges. This presumption is supported by our finding that WTP for the combined porridges increases with higher frequency of cowpea leaf consumption.

With respect to the role of information, we found that giving additional information about the products was partly helpful in improving their demand. Our results showed that the WTP for the millet porridges was higher among participants who received further information on their nutritional value. This suggests that participants appreciate knowing about the food they purchase, and confirms results of several other studies conducted in this field (Chowdhury et al. 2011; De Groote et al. 2014; Oparinde et al. 2016). Interestingly, we could not observe the relationship between information and WTP for the maize porridges. We propose that this is due to consumers being aware of the general fact that millet has a higher nutritional value than maize (Orr, Mwema, and Nedumaran 2016) and the given information confirmed their believes. The phenomenon of people tending towards information that is in accordance to their beliefs has already been studied in the field of psychology and is often referred to as confirmation bias (Nickerson 1998). It is our interpretation that giving nutrition information is more persuasive if some form of nutritional perception already exists.

In sum, it is interesting that different porridge types were perceived differently, and that distinct ways of promotion might be fruitful for each porridge type. While information campaigns drawing on the benefits of CLP could successfully advertise CLP-enhanced millet porridge, a different approach might be necessary for CLP-enhanced maize porridge which stands to reason if we consider that maize porridge is of low nutritional value.

We employed only one mixture ratio of porridge flour and CLP throughout the project. The ratio was based on a pre-study determining the highest amount of CLP that was still considered acceptable. We clearly find a trade-off between nutrition enhancement and the loss of consumer acceptance.

Regarding our control variables we found that younger and less educated participants, who are generally likely to have less cooking knowledge and skills, were especially willing to pay for the plain, non-enhanced porridges, which stresses its suitability to reach vast parts of the population at issue. The analysis also shows that the plain porridge's

sensory perception did not play a significant role in shaping consumers' WTP. We assume that porridge is predominantly consumed for caloric intake and not taste.

Limitations

When assessing our findings, we need to elaborate on some limitations of the survey conducted. First, it could be promising to add cowpea leaves to other suitable food items, like soups or relishes, where their influence on sensory characteristics could be less dominant.

Second, we only studied adults. Since nutrient-poor porridges are often used as a complementary food for children in rural areas (Oladiran and Emmambux 2020), those children would be an important target group of nutritionally enhanced porridges and should be considered in future studies. Moreover, we analyzed consumers as individuals. Since dietary patterns are significantly shaped by social norms and community practices (Kiguli et al. 2019), it could prove fruitful to add a complementary sociological dimension to this area of research.

Third, while the BDM-auction has the benefit of being applicable at the point of purchase, the environment is difficult to control which can influence consumers responses. Consumers are selected spontaneously and sometimes are in a hurry to finish the study. Although, the experiment was incentive driven to ensure everybody was interested to provide an adequate response and theoretically able to purchase the product, it does not reflect all details of a market purchase. Nevertheless, the method has been applied several times and shown to provide reliable data (De Groote et al. 2014; 2018; 2020). Moreover, the setup of the survey was challenging. Since we conducted the survey in outdoor markets, almost 20% of cases had to be removed from further analysis, as sudden weather changes caused disruption and participants left without finishing the survey.

Finally, this resulted in a small sample size, leads to results not being conclusive for minor effects. Thus, we can only show tendencies towards the products and not draw causal relations.

4.5 Conclusion

Using sensory analysis and WTP, we assessed the potential of enhancing conventional porridges with cowpea leaf powder as a channel to promote inclusion of locally available, nutritious vegetables into meal plans in East Africa.

Descriptive results show that sensory scores are lower among CLP-enhanced porridges, as compared to plain porridges. Still, almost half of the consumers rated them at least equally high in terms of WTP, with the general consumption of fresh cowpea leaves being higher in this group. Thus, CLP-enhanced porridges are unlikely to replace plain ones but could provide an alternative for some consumers.

Based on our findings, we make the following recommendations. First, priority in future research should be given to sensory attributes relative to conventional products when enhancing their nutritional value. Second, it is important to find ways to reach consumers who barely, or do not, incorporate fresh vegetables into their dietary habits. Third, education is necessary to sensitize consumers to the importance of diverse and nutrient-rich diets. We expect that a healthy image of the products, which could be generated through information, could be helpful in a mix of marketing measures to promote the products. Fourth, governments should support the utilization of locally available nutritious vegetables to enhance nutrition and lower postharvest losses simultaneously. This could include supporting training on techniques of processing ALV, as well as education campaigns that raise awareness about dietary quality and nutritional benefits of ALV.

4.6 Appendix

Table A. 7: Participants characteristics, by information

Characteristics	Information Mean (SD)	No information Mean (SD)	p
Female (%)	1.75 (0.44)	1.68 (0.47)	0.570
No. household members	4.98 (2.51)	5.30 (2.38)	0.310
Years in formal education	7.04 (3.76)	8.00 (2.84)	0.07*
Children 6 to 59 month (binary)	1.79 (0.41)	1.80 (0.40)	1.000
Frequency cowpea leaf consumption	4.29 (2.08)	3.78 (2.27)	0.390
Frequency porridge consumption	7.02 (1.13)	6.90 (1.34)	0.830
Nutrition awareness (factor)	-0.07 (0.97)	0.07 (1.03)	0.460
Color millet	4.19 (1.21)	4.34 (0.96)	0.670
Aroma millet	3.94 (1.16)	4.04 (1.11)	0.670
Texture millet	4.40 (0.91)	4.34 (0.82)	0.470
Taste millet	4.33 (1.04)	4.22 (1.13)	0.740
General appearance millet	4.52 (0.64)	4.58 (0.70)	0.430
Color maize	3.67 (1.32)	3.84 (1.35)	0.450
Aroma maize	3.62 (1.40)	3.82 (1.24)	0.560
Texture maize	3.87 (1.51)	4.04 (1.26)	0.860
Taste maize	4.13 (1.14)	4.22 (1.06)	0.730
General appearance maize	4.17 (1.10)	4.36 (0.88)	0.510
Color clmaize	2.33 (1.42)	2.92 (1.31)	0.02**
Aroma clmaize	2.73 (1.42)	2.98 (1.38)	0.360
Texture clmaize	3.06 (1.43)	3.34 (1.35)	0.330
Taste clmaize	3.23 (1.28)	3.28 (1.43)	0.770
General appearance clmaize	3.21 (1.27)	3.54 (1.27)	0.190
Color clmill	3.02 (1.36)	3.52 (1.28)	0.06*
Aroma clmill	2.87 (1.40)	3.00 (1.23)	0.580
Texture clmill	3.15 (1.56)	3.28 (1.34)	0.730
Taste clmill	3.56 (1.42)	3.64 (1.17)	1.000
General appearance clmill	3.58 (1.23)	3.56 (1.16)	0.900

Table A. 8: Structural equation model including control variables

N = 102	Millet			Maize		
	Coef.	SE[a]	p	Coef.	SE[a]	p
Female	-0.107	0.092	0.246	-0.125	0.057	0.029**
Age (years)	-0.319	0.126	0.011**	-0.372	0.142	0.009***
Education (years of schooling)	-0.248	0.007	0.000***	-0.150	0.021	0.000***
Information	0.186	0.079	0.019**	0.166	0.118	0.158
Nutrition (factor)	0.283	0.070	0.000***	-0.022	0.114	0.848
Sensory perception (factor)	-0.022	0.096	0.814	0.109	0.118	0.358

	Millet porridge combined with CLP			Maize porridge combined with CLP		
	Coef.	SE[a]	p	Coef.	SE[a]	p
wtp_millet	0.578	0.068	0.000***			
wtp_maize				0.397	0.282	0.158
Female	0.009	0.068	0.892	-0.012	0.062	0.851
Age (years)	-0.016	0.041	0.702	-0.082	0.094	0.383
Education (years of schooling)	0.041	0.090	0.646	-0.077	0.078	0.323
Freq. cowpea leaf cons.	0.120	0.022	0.000***	0.026	0.027	0.350
Information	0.099	0.052	0.056*	0.159	0.115	0.168
Nutrition (factor)	-0.103	0.093	0.271	0.104	0.118	0.380
Sensory perception (factor)	0.269	0.057	0.000***	0.239	0.024	0.000***

[a] Standard errors are robust and clustered at market level

* reflects significance at 10%,

** reflects significance at 5%, *** reflects significance at 1%

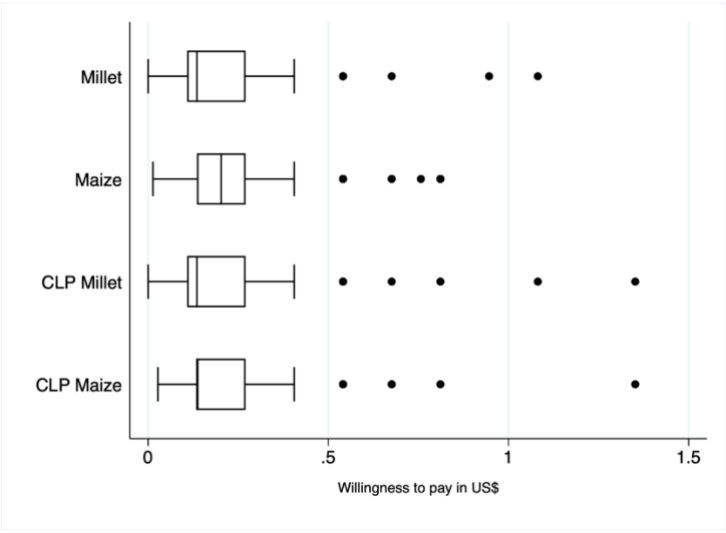


Figure A. 4: Willingness to pay distribution

5 Acceptability of jackfruit-nut-bars as a healthy snack in Uganda[5]

Abstract:

The growing prevalence of ultra-processed foods in Uganda is driving the double burden of malnutrition. Overweight and obesity are on the rise while the intake of micronutrients remains insufficient. Simultaneously, jackfruits that are rich in minerals and vitamins remain underutilized. Its large size, sticky insides, and high perishability make it challenging to handle and cause high postharvest losses. In an attempt to address both issues, the present study investigates the potential of long-lasting, nutritious, and sugar-free jackfruit-nut-bars (JNBs) as a channel to enhance and promote the utilization of jackfruit, and provide healthier options of processed foods. To analyze consumer demand for the products, we first assess the sensory perception of four different JNBs at a university campus in Uganda. We then use Van Westendorp's price sensitivity meter to elicit consumers' willingness to pay (WTP) and identify factors shaping their demand. The results show that the sensory properties are, on average, rated positively, and price preferences are similar to established snacks. Based on our findings, we conclude that JNBs provide an option to enhance jackfruit utilization. A random effects model shows that WTP increases with sweetness, age, and frequency of snack consumption that JNBs can potentially substitute. These findings help future development and promotion of processed jackfruit products.

[5] This paper is co-authored by Dominic Lemken (DL). JT and DL developed the research idea, JT collected the data, analyzed the data, and wrote the paper. DL commented at all stages of the research and contributed to writing and revising the paper.

5.1 Introduction

The supply and consumption of ultra-processed foods are rapidly growing in Africa (Baker et al. 2020). These diets are characterized by high fat, sugar, and salt intake which, are significant contributors to non-communicable diseases and obesity (Auma et al. 2019). Since they are low in minerals and vitamins, this trend leads to an increasing prevalence of double burden of malnutrition (Reardon et al. 2021), which means that the same person can be overweight or obese and still deficient in micronutrients. In Uganda, deaths caused due to non-communicable diseases increased from 31 to 36% from 2015 to 2019 (The World Bank 2021). Baalwa et al. (2010) estimate around 12% prevalence of overweight and obesity among young adults, who are aged between 18 and 30 years in Kampala, a more previous study on women of reproductive age finds rates around 16% (Yaya and Ghose 2019). Thus, there is a need to develop products that meet consumer preferences but provide higher dietary quality and do not add to the current burden of malnutrition.

Beyond this background, it could be promising to expand the use of highly nutritional but underutilized indigenous fruits, such as jackfruits. Jackfruits (*Artocarpus heterophyllus* Lam.) grow naturally in Uganda and provide valuable nutritional profiles, including carbohydrates, proteins, vitamins, minerals, and dietary fiber (Ranasinghe et al., 2019). Moreover, they can grow in a diverse spectrum of climatic conditions and can thus, play an important role in the face of climate change (Nakintu et al. 2019). However, farmers in Uganda grow jackfruit mainly for home consumption and experience losses ranging between 15 and 50% (Balamaze et al. 2019). Their utilization is hampered by their large size, sticky insides, and short shelf life (Ranasinghe, Maduwanthi, and Marapana 2019). Simple processing techniques are recommended to overcome the current obstacles and develop nutritious, easily accessible, long-lasting food products (Ranasinghe, Maduwanthi, and Marapana 2019). Previous literature demonstrated that the fruit is suitable for being processed into various products such as jackfruit chips, wine, jam, or jackfruit-nut-bars (Nansereko and Muyonga 2021; Xing, Keding, and Pawelzik 2021). However, there is no common knowledge about consumers' demand for processed jackfruits in Uganda.

The present paper addresses this issue by analyzing consumer demand for jackfruit-nut-bars (JNBs); it does so by combining sensory analysis with Van Westendorp's price sensitivity meter (PSM). Recent literature demonstrated the value of PSM when

implementing novel food products on the market (Weinrich and Gassler 2021). JNBs are chosen, on one hand, because they are rich in minerals and nutrients, entirely plant-based, and without added sugar. On the other hand, they provide benefits commonly attributed to processed foods, such as time-saving preparation and consumption, no requirement of preparation knowledge, and suitability for out-of-home consumption (Sauer et al. 2021; Xing, Keding, and Pawelzik 2021). Additionally, JNBs are optimal snacks that can positively impact cognitive performance and physical activity (Masoomi et al. 2020). Due to their convenience and nutritional characteristics, they offer a healthier alternative to currently existing products in the market.

Our work offers the following contributions to existing literature: first, while earlier research examined the nutritional value of jackfruits and their potential for processing, there is no current insight into consumers' demand for processed jackfruit products. Second, we gain a first impression of how consumers receive sugar-free snacks. Third, an economic evaluation of consumers' willingness to pay (WTP) for the products allows us insights into consumers' price preferences and, thus, the product's competitiveness in the market. Finally, analyzing factors that shape consumers' demand provide approaches for future successful development and implementation of processed jackfruit products.

The paper is organized in the following manner: Section 5.2 describes the methods that are applied, along with a description of the product, study site, and data collection; Section 5.3 will present the results and their discussion; Section 5.4 concludes the paper.

5.2 Methods

5.2.1 Product

Jackfruit is globally the largest edible fruit. The jack tree has high productivity and can yield up to 700 fruits per year. The weight of the fruits varies between 0.5 to 50 kilograms (Rahman et al. 2016). The bulbs inside the fruits are the edible part. The fruits are held together by laticiferous cells that produce latex and make handling of jackfruits difficult. In Uganda, jackfruits are available all year-round, with the highest yields in December and January (Nakintu et al. 2019).

Our analysis is built on four JNBs that were slightly different from each other. Project colleagues from Göttingen University developed the recipes for JNBs. All JNBs consisted of jackfruit, peanuts, mango, and lemon. In addition, desiccated coconut was added to

two JNBs since previous research from Nigeria demonstrated an increase in flavor through coconut in breadfruit snacks (Okafor and Ugwu 2014). The ingredients were mixed and roughly blended. Two mixtures, one with coconut and one without, were finely puréed into a homogenous mixture. The remaining two products were kept crispy to analyze the effect of texture on consumer preferences. All four mixtures were oven-dried (Table 15). The ingredients were sourced from local markets in Kampala, Uganda. The products were prepared freshly by a project colleague at Makerere University for the study. Combining fruits with nuts lead to high mineral contents in the final products (Xing, Keding, and Pawelzik 2021). The mineral contents for the puréed JNB with coconut are available in Table 16. Since differences between the JNBs were small, we do not expect significantly different results for the remaining products.

Table 15: Product overview

	Plain	**Puréed**	**Coco**	**Coco & Puréed**
				
Ingredients	Jackfruit (60) Peanuts (10) Mango (20) Lemon juice (10)	Jackfruit (60) Peanuts (10) Mango (20) Lemon juice (10)	Jackfruit (55) Peanuts (18) Mango (9) Lemon juice (9) Desiccated coconut (9)	Jackfruit (55) Peanuts (18) Mango (9) Lemon juice (9) Desiccated coconut (9)
Preparation technique	Roughly blended	Finely puréed	Roughly blended	Finely puréed

* % of each ingredient in the final product in parentheses

Table 16: Mineral contents of the puréed JNB with coconut

Mineral	mg/ 100g DM[1]
Potassium (K)	1214.03
Phosphorus (P)	358.52
Sulfur (S)	211.00
Magnesium (Mg)	174.73
Calcium (Ca)	80.05
Sodium (Na)	40.72
Copper (Cu)	5.91
Iron (Fe)	5.20
Zinc (Zn)	6.86
Manganese (Mn)	2.32

[1] Displayed are the nutrient contents after drying
Source: Xing, Keding, and Pawelzik 2021

5.2.2 Study site and participants

We collected data from students and staff at Makerere University in Kampala, Uganda, based on the following criteria: 1) being at least 18 years old; free of diabetes or any other diet-related restriction; willing to taste four different JNBs. Participants were selected based on their availability and willingness to take part in the study, which was conducted in March 2020. The enumerators informed the participants about their right to leave at any time and asked them to give their written consent. All study participants received 4000 Ugandan Shillings (UGX) (1 US$ = 3669 UGX at the time of the survey) to express our gratitude.

5.2.3 Data collection

Trained enumerators collected data using electronic tablets. The first part of the survey comprised a structured questionnaire that addressed the socio-demographic characteristics of participants. Following which, the participants received about 10 g of each JNB, shaped in squares, one at a time. The order was randomized. The participants were asked to rate each JNB on color, aroma, texture in the mouth, taste, and general appearance using a five-point Likert scale, with values ranging from 1 = dislike it very much, 2 = dislike it, 3 = neither like nor dislike it, 4 = like it, and 5 = like it very much.

Further, participants were asked to rate the sweetness and fruit flavor of the JNBs on a just-about-right scale, with values ranging from 1 = much too sweet, 2 = slightly too sweet, 3 = just about right, 4 = somewhat not sweet enough, and 5 = very much not sweet enough for sweetness and 1 = much too weak, 2 = somewhat too weak, 3 = just about right, 4 = somewhat too strong, and 5 = much too strong for fruit flavor. We used symbols to label the different bars. This way, we ensured double-blind testing since neither enumerator nor study participant knew the difference between the JNBs. Between testing, participants were asked to rinse their mouths with water.

After the sensory analysis, PSM was used to assess participants' WTP for each JNB. PSM helps provide first insights about optimal prices for a novel product (Van Westendorp 1976). The approach forces consumers to think about price ranges (Chhabra 2015). The PSM included the following questions about each JNB:

(1) At what price would you consider the product to be too expensive that you would not consider buying it?
(2) At what price would you consider the product to be too cheap that you would doubt its quality and not consider buying it?
(3) At what price would you consider the product to be getting expensive, but you would still consider buying it?
(4) At what price would you consider the product to be getting cheap that you would consider it to be a bargain?

The participants were asked to answer these questions for 200 g packs of the JNBs. A 200 g packet of cookies was provided as a reference quantity. As it is commonly done with PSM, the data were analyzed graphically to display cumulative distributions at different price points. Following the PSM, the survey was concluded with general questions about participants' consumption habits and attitudes using a structured questionnaire, including open questions about what they dislike and like most about jackfruits.

5.2.4 Statistical analysis

To get a general idea about factors that influence the demand for JNBs, we ran one model across all four products simultaneously. Thus, we combined the four JNBs to one and calculated the mean of the four price questions: too cheap, cheap, expensive, and too expensive. We used a random effects model to account for participants who state their WTP four times, once per JNB. We used the following model to fit the data:

$$WTP_{ij} = \alpha + x_{ij}\beta + \varepsilon_i\gamma + v_i + \epsilon_{ij} \quad (5)$$

WTP_{ij} is the willingness to pay of the i^{th} participant for the j^{th} JNB. $x_{ij}\beta$ describes the explanatory variable that is alternative-specific, thus changing between the JNBs such as perceived sweetness. Explanatory variables that are case-specific, which implies they do not vary across JNBs, such as socio-demographic variables, are denoted by $\varepsilon_i\gamma$. v_i displays the random effect and ϵ_{ij} the error term.

A special concern in the production of these bars was to add no industrialized sugar. Therefore, we included "sweetness" as an independent variable, in addition to socio-demographic characteristics, namely age, sex, and number of people living in the households. Moreover, we included frequency of snack consumption, control of families' sugar intake, and participants' food neophobia in the model. The frequency of snack

consumption was measured on a scale ranging from 1 = never to 8 = daily, and control of families' sugar intake was measured on a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. Food neophobia is a factor derived from five different statements towards new food (Table 17). The sampling adequacy was determined via Bartlett's test and the Kaiser-Meyer-Olkin (KMO) criterion. The internal consistency was determined via Cronbach's-α. The KMO value of 0.72 and Cronbach's-α value of 0.74 were considered acceptable. The enumerator effect was included as a control variable. The analysis was carried out using Stata 16.

Table 17: Factor analysis of food neophobia of the study participants

	Neophobia factor Factor loadings
I am afraid to eat food I did not eat before.[1]	0.85
I do not trust new food.[1]	0.79
I constantly try new foods (reversed). [1]	0.80
I am very particular about the food I eat. [1]	0.75
I eat almost anything (reversed). [1]	0.88
Cronbachs-α	0.74
KMO	0.72

[1] Scale: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree

5.3 Results and discussion

5.3.1 Participant characteristics

The sample comprises 93 people, who are primarily young and well-educated students with an average age of 28 years and 14 years spent in formal education. Almost half of the participants are females, who live, on average, in households of five people (Table 18). The study participants consume fresh jackfruits mainly due to their taste (44%), and the majority dislike its sappiness (61%).

The descriptive results of participants' food neophobia reveal that participants tend to be relatively open toward trying novel products. Less than one-third of the sample agrees to the statement "I do not trust new food." and "I am afraid to eat food I did not eat before.". Over 60% state that they constantly try new foods.

Table 18: Participant characteristics

Characteristics (n = 93)	Mean	Std. Dev.	Min	Max
Sociodemographic				
Female	48%			
Age (years)	28.29	11.29	18	61
No. household members	5.05	3.03	1	17
Years in formal education	14.51	3.76	1	23
Reasons for Jackfruit consumption[1]				
Taste	44%			
Health	25%			
Availability	8%			
Dislike about Jackfruits[1]				
Sap	61%			
Perishability	9%			
Strong smell	9%			
Food Neophobia[2]				
I am afraid to eat food I did not eat before.	2.31	1.40	1	5
I do not trust new food.	2.28	1.27	1	5
I constantly try new foods.	3.75	1.18	1	5
I am very particular about the food I eat.	3.01	1.28	1	5
I eat almost anything.	3.08	1.45	1	5

[1] Open question, listed are the three most frequently stated reasons; [2] 5-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree;

Most participants consume fruits at least twice a week (Table 19). Only one participant consumes processed jackfruit products, namely jackfruit crisps. Over 70% consume snacks at least twice a week. Sugared snacks are consumed a little less frequently, with 25% indicating to consume them daily and 32% to consume them two to three times per week (Table 19). Our finding that less than 30% of the participants consume fruits daily aligns with previous research that shows that insufficient fruit consumption in Uganda occurs among various social classes (Kabwama et al. 2019). This fact reinforces concerns about general dietary quality among the urban population in Uganda, especially considering that in our sample, sugared snack consumption is almost as high.

Table 19: Consumption frequencies

	Fruits (%)	Fresh Jackfruit (%)	Processed Jackfruit (%)	Snacks (%)	Sugared Snacks (%)
Never	2.15	9.68	98.92	3.23	5.38
Less than once per month	1.08	9.68	0	1.08	4.30
Once per month	1.08	21.51	0	6.45	8.60
2 to 3 times per month	4.30	12.90	0	5.38	2.15
Once per week	13.98	15.05	0	9.68	15.05
2 to 3 times per week	37.63	18.28	1.08	26.88	32.26
4 to 6 times per week	10.75	4.30	0	10.75	6.45
Daily	29.03	8.60	0	36.56	25.81
N	93	93	93	93	93

5.3.2 Sensory analysis

On average, all sensory characteristics show a slight tendency of being liked, with mean scores above 3 (“neither like nor dislike it”) (Table 20). The only exception is the score for texture in the mouth for the JNB with coco, which is rated slightly lower. The plain JNB received the highest score for color, the puréed JNB the highest for texture in the mouth, and the puréed JNB with coco the highest score for aroma, taste, and general appearance. However, the differences between the plain JNB and the puréed JNB with coco are insignificant for aroma and general appearance. Most characteristics receive scores of “like it” and “like it very much” by more than 50% of the participants. It is noticeable that texture in the mouth for the two bars that are not puréed receive significantly lower scores than their counterparts. The findings indicate that the soft texture of the puréed bars is preferred. The sensory scores of all four JNBs are displayed in Figure A. 5.

Participants did not rate the sweetness between the JNBs with any statistically significant difference. The fruit flavor of the puréed JNB with coco is perceived as strongest. It is rated significantly higher than the fruit flavor of the puréed JNB and coco JNB. We find that between 56 and 59% of the participants rate sweetness, and between 47 and 55% rate the fruit flavor of all JNBs as just about right. According to the t-test, neither sweetness nor fruit flavor is rated significantly different from 3 = just-about-right for any product. That sweetness being perceived as just-about-right is a welcome finding, considering the absence of sugar. The variance of all JNBs combined (Total) suggests heterogeneity within participants’ scores across the products. This implies that high scores for JNBs are not necessarily obtained from the same participants, which indicates that different participants preferred different JNBs.

In summary, these findings indicate that the differences between the single bars are small, and no JNB can be identified as superior to the others. Since we find variability in participants’ scores across the products, we believe that providing more than one kind of JNB allows for developing larger market shares.

Table 20: Mean results of the sensory analysis

	Plain	Puréed	Coco	Coco & Puréed	Total
Color	3.86[a] (1.03)	3.61[b] (1.06)	3.31[c] (1.15)	3.51[bcd] (0.98)	3.59 (1.07)
Aroma	3.63[a] (1.05)	3.22[b] (0.98)	3.15[bc] (0.99)	3.69[ad] (.98)	3.44 (1.00)
Texture in the mouth	3.11[a] (1.02)	3.61[b] (1.07)	2.90[ac] (1.23)	3.57[bd] (1.06)	3.31 (1.14)
Taste	3.54[a] (1.06)	3.42[ab] (1.14)	3.42[abc] (1.07)	3.74[d] (1.09)	3.53 (1.10)
General appearance	3.63[a] (0.89)	3.60[ab] (0.95)	3.49[abc] (0.94)	3.82[ab] (0.87)	3.64 (0.92)
Sweetness[1]	2.96[a] (0.82)	2.92[a] (0.78)	2.84[a] (0.8)	2.98[a] (0.79)	2.91 (0.80)
Fruit flavor[2]	3.01[a] (0.87)	2.88[ab] (0.99)	2.98[ab] (.86)	3.12[ad] (0.91)	2.99 (0.91)
N	93	93	93	93	372

Note: mean coefficients, sd in parentheses; different letters a,b,c, and d reflect significant differences ($p < 0.05$) in a characteristic between the JNBs according to Kruskal-Wallis and Duncan-T; [1] scale: 1 = much too sweet, 2 = slightly too sweet, 3 = just about right, 4 = somewhat not sweet enough, and 5 = very much not sweet enough; [2] scale: 1 = much too weak, 2 = somewhat too weak, 3 = just about right, 4 = somewhat too strong, and 5 = much too strong

5.3.3 Price sensitivity meter

Each participant had to state four prices (too cheap, cheap, expensive, and too expensive) for each JNB. Thus, in total, 372 statements were made. Before analyzing the PSM, we checked participants' answers for plausibility. Statements had to comply with the following order: too cheap < cheap < expensive < too expensive. We kept 297 statements for further analysis.

The findings from the analysis of PSM display homogeneity across products (Table 21). While prices of approximately 0.55 US$ are perceived as being too cheap, prices of approximately 2 US$ are perceived as being too expensive. We cannot find any statistically significant differences between the JNBs according to Kruskal-Wallis ($p < 0.05$).

Table 21: Descriptive results of the price sensitivity meter

	Plain	**Puréed**	**Coco**	**Coco & Puréed**
Too cheap	0.514	0.605	0.536	0.571
	(0.478)	(0.549)	(0.411)	(0.456)
Cheap	0.745	0.885	0.760	0.791
	(0.590)	(0.774)	(0.490)	(0.533)
Expensive	1.434	1.623	1.474	1.534
	(1.176)	(1.143)	(1.310)	(1.114)
Too expensive	1.867	2.299	1.993	2.093
	(1.421)	(2.070)	(1.472)	(1.439)
N*	74	76	73	74

Note: mean coefficients, sd in parentheses; We could not find any statistically significant differences between the products for $p < 0.05$ according to Kruskal-Wallis

Therefore, we combined the results of all four JNBs to one variable to further evaluate PSM. The proportion of participants who find the price up to a certain level as being "too expensive," "expensive," "cheap," or "too cheap" were calculated for different price points. The graphical results are displayed in Figure 11. Four intersections can be identified that should be considered for further product marketing. First, is the optimal price point (OPP), at which this point, the proportions of participants who consider JNBs as being "too expensive" or "too cheap" are equal. For the JNBs, we find the OPP at 0.82 US$. The price at this point is optimal in terms of maximizing sales volume or market share. Similarly, prices for 200 g of cookies range around 1 US$. Cookie prices were obtained from markets in Kampala, Uganda. The second intersection is the indifference price (IDP), at which the proportions of participants who consider JNBs as being "expensive" or "inexpensive" are equal. The price that results at this point describes a balanced price-image relationship. Based on the target product, it is generally the average price that market-leading companies can achieve. For the JNBs, IDP is equal to OPP. The finding is common and indicates that the product neither has a negative image, which would lead to an OPP lower than IDP, nor an especially innovative character, which would lead to an OPP higher than IDP.

The final two intersections can be used to determine an optimal price range. The threshold of relative cheapness (Point of Marginal Cheapness) represents the lower price barrier. A price below this point could cause damage to the image of JNBs. The point of marginal expensiveness results in the upper price barrier. Potential buyers will hardly accept higher prices. For the JNBs, we find an optimal price range between 0.68 US$ and 1.09 US$.

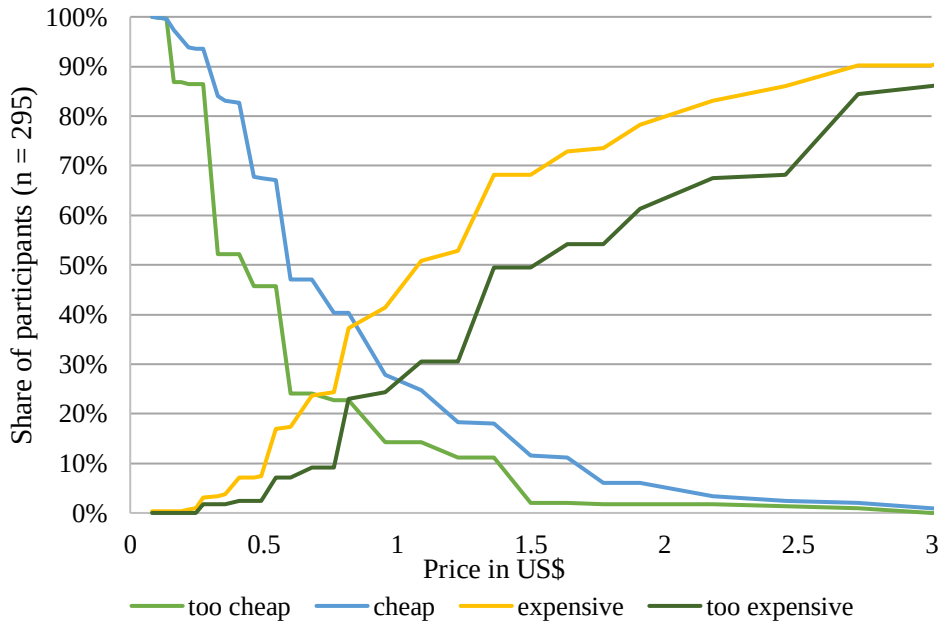


Figure 11: Graph of price sensitivity meter (all four JNBs combined). Displayed are the participant shares against the price for 200 g of JNBs

Random effects model

For the random effects model, we calculated mean of the four prices as the dependent WTP variable; Table 22 presents the results. The model estimates four variables to significantly affect participants' WTP: sweetness, age, frequency of snack consumption, and an interaction between age and sweetness. Age, sweetness, and frequency of snack consumption positively impact WTP. Sweetness shows the strongest impact. A one-unit increase in sweetness increases participants' WTP by 0.27 US$. The effect is predominant for younger participants. The positive relation between frequency of snack consumption and WTP indicates that JNBs are in line with currently consumed snacks and thus, emphasizes their potential to substitute unhealthier alternatives.

The positive effect of age might be due to our general young sample with an average age of 28 years. We believe that the sweetness effect is predominant among younger participants since their diets might be higher in sugared foods and beverages (Isabirye et al. 2020). Therefore, their taste buds are likely to be already adapted to sweetness. This finding is important for future research that aims to improve diets among these population

groups. Moreover, previous studies reveal that liking sweet taste is associated with total energy, carbohydrate, and sugar intake (Jayasinghe et al. 2017). This draws attention to the need to provide healthier alternatives.

Before concluding, we need to elaborate on some shortcomings of our study. We questioned only a small and homogenous number of consumers. The findings give some valuable first insights towards the perception of JNBs and provide starting points for follow-up research. Addressing additional parts of society could help identify further channels to sell jackfruit products. The JNBs can, for instance, be easily implemented as healthy snacks into school diets. Thus, research among children and students is a possible way forward.

Table 22: Results of random effects model

Willingness to pay[1]	Coefficient	St.Err.[2]	t-value	p-value	[95% Conf	Interval]	Significance
Sweetness	.27	.115	2.35	.019	.045	.496	**
Age (years)	.021	.012	1.72	.086	-.003	.044	*
Female (binary)	.142	.14	1.01	.311	-.132	.416	
No. of people living in the household	-.037	.044	-0.84	.402	-.122	.049	
Frequency of snack consumption	.115	.05	2.32	.02	.018	.212	**
I control my families' sugar intake	-.042	.058	-0.72	.472	-.157	.073	
Neophobia (factor)	.145	.089	1.64	.101	-.028	.319	
Age#Sweetness	-.005	.003	-1.65	.099	-.012	.001	*
Constant	-.687	.534	-1.29	.198	-1.734	.359	

Mean dependent variable	1.216	SD dependent variable	0.853
Overall r-squared	0.113	Number of observations	293
Chi-square	28.146	Prob > chi2	0.005
R-squared within	0.038	R-squared between	0.123

*** *p<0.01*, ** *p<0.05*, * *p<0.1*, the enumerator effect is included as a control variable

[1] Willingness to pay is the mean of the four price sensitivity meter items (too cheap, cheap, expensive, and too expensive)

[2] Standard errors are robust

5.4 Conclusions

Processing is perceived as the way forward to enhance jackfruit utilization in Uganda. Concurrently, processed food consumption is often associated with overweight and obesity. Jackfruit-nut-bars are an option to process jackfruits into long-lasting products that are rich in minerals and vitamins but are free of added sugar, salt, and oil. However, to implement the product successfully in the market, it is required that consumers demand them. This paper examines consumers' demand for four different types of JNBs.

Based on the sensory perception of and willingness to pay for the products, the findings suggest that JNBs can provide an alternative to the existing unhealthy snacks in the market. Still, there is need to provide a variety of JNBs to address different consumers. Simultaneously, the findings indicate that it is possible to derive sweetness in snacks solely from natural plants without adding industrialized sugar. The finding is important in the face of growing obesity rates in Uganda. Still, sweetness is an important factor that drives demand and should be considered in future development of jackfruit products.

5.5 Appendix

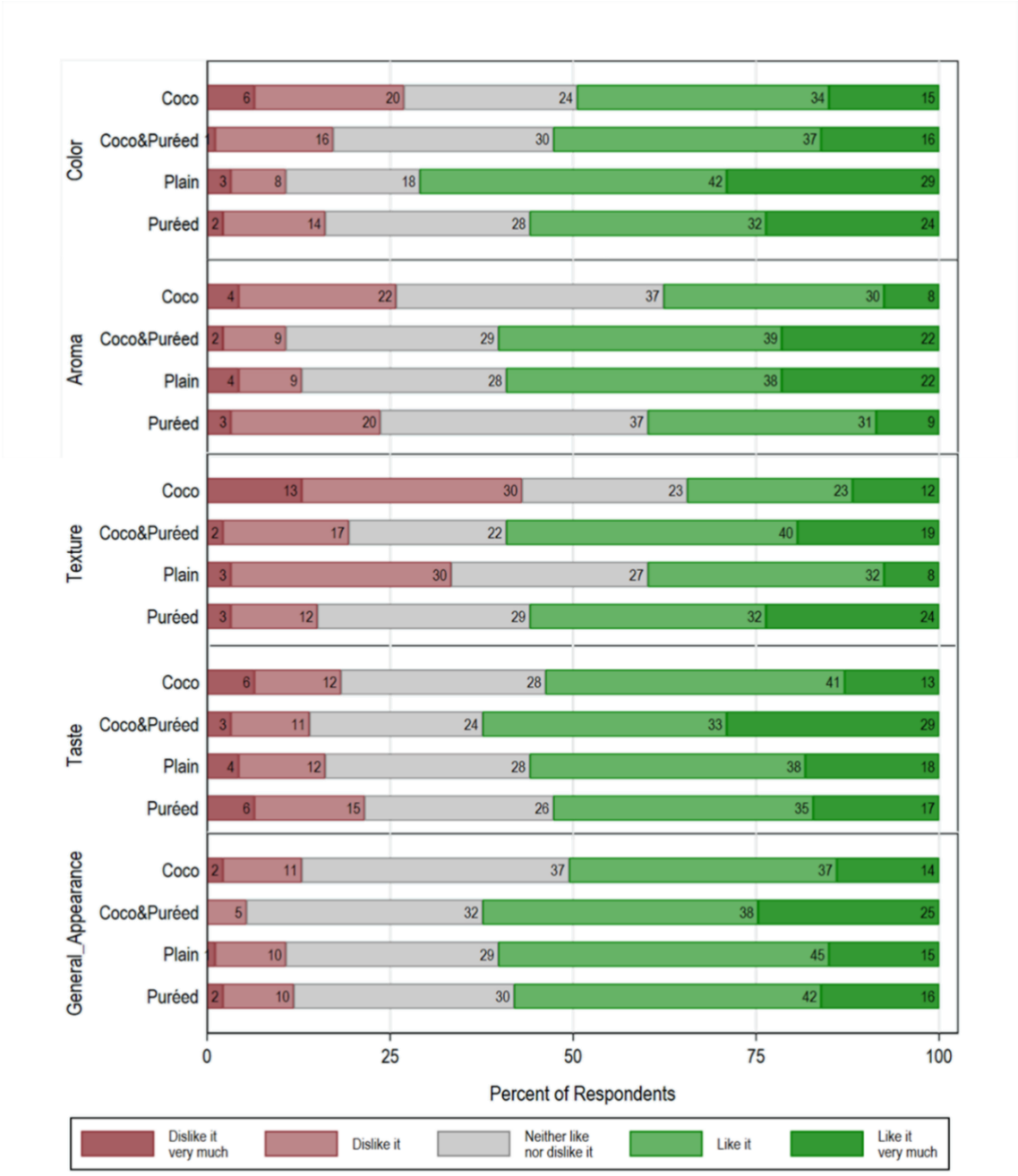


Figure A. 5: Results of the sensory analysis, n = 93

6 General conclusion

Enhancing the utilization of indigenous fruits and vegetables (IFV) and reducing postharvest losses will be of high relevance to rural development, economic growth, improving food security for a growing population, responsible consumption and production, and thus, achieving several of the United Nation's sustainable development goals (2,3,8,12). Despite the increasing evidence of their nutritional and economic potential, many plant species remain underutilized and are viewed as poor people's plants. This doctoral thesis aims to contribute to the existing literature by analyzing the market potential of IFV products. The papers offer insights into the potential of different processed products that can act as channels to improve access to nutritious food and the perception of indigenous plants. Consequentally, this thesis offers a more comprehensive understanding of how to successfully market IFV products in East Africa. The results can assist in promoting the utilization of indigenous plants and in deriving promising marketing strategies that support their local distribution.

Paper 1: Consumer demand for processed IFV

We find that demand for processed IFV generally exists. This is a welcome finding indicating that processing can overcome the poor reputation of IFV. However, due to increasing discussion about the health impacts of processed foods, there is a need to emphasize nutrient-sensitive techniques and to distinguish processed products as either healthy or unhealthy based on their nutrient value and not only their processing level. Furthermore, while sensory perception is a significant factor shaping market demand, other components, such as socio-demographic characteristics, are also important to consider when placing the products on the market. Indeed, our results indicate that women and the rural population are more reluctant to pay increased prices for the majority of the nutrient-rich products, despite controlling for their wealth. These findings make an important contribution to evaluating IFVs' contribution to food security. Women and the rural population are often more prone to micronutrient deficiencies and would thus greatly profit from year-round access to nutritious foods. It will be necessary for future research to consider the food consumption drivers of these consumer groups to understand how their demand for IFV products can be enhanced. This includes analyzing culinary practices and identifying how the products fit best. Additionally, reducing refusal of novel products could also be achieved by educating households about suitable processing techniques, thereby demonstrating their safety. One key conclusion of this dissertation is that while the products are well perceived and demanded by many consumers, the potential to bridge off-season gaps depends on effectively targeting micronutrient deficient consumer groups. Insights from other

food types demonstrate that, for example, women's food choices are predominantly shaped by income and food prices (Downs et al. 2022; Cornelsen et al. 2016). However, as we controlled for wealth in our analysis, we assume it is not the reason for women's price penalty concerning IFV products. Other factors found in previous studies might be more probable in our context. Consumers' cooking skills and perceptions towards food safety are major factors to consider.

Paper 2: Economic valuation of processed IFV

Beyond impacts on consumer demand, processing is also associated with higher incomes for farmers. Our results provide some evidence that processing allows for promising surpluses. Therefore, we believe that it can play an essential role in rural development. Spillover effects for other parts of the rural community are likely. These could include advanced demand for other ingredients, packaging materials, and transport, which would lead to increasing income, and new job opportunities. Nevertheless, our findings also underline the importance of marketing strategies aligned with the specific products to establish the products on the market in the long run. In particular, considering traditional backgrounds of food consumption and familiarizing consumers with the processors could be promising approaches in certain areas.

Paper 3: Enhancing conventional porridges with cowpea leaf powder

Furthermore, we show that combining conventional food with indigenous vegetables as a channel to implement cowpea leaves in diets brings heterogeneous effects. Our results suggest that adding cowpea leaf powder to porridges is not without economic risks. The combination lowers sensory perception but can add nutritional diversity to a niche group of consumers. We also find heterogeneity regarding the success of additional information to increase demand, possibly due to prejudiced knowledge about conventional products. For instance, informing the participants about the nutritional value of millet porridge combined with cowpea leaves had a positive effect. However, no effect of information was found on maize porridge combined with cowpea leaf powder. This draws attention to the fact that information campaigns need to be product and consumer-sensitive, which resonates with our findings from paper 1. The findings indicate a need for education campaigns informing about the value of cowpea leaves. Moreover, highlighting that the porridges are suitable for children could also be successful, as porridge is widely used as a complementary food.

Paper 4: Analyzing demand for jackfruit-nut-bars

For the jackfruit-nut-bars, we find that sweetness of the products is the dominant driver shaping consumers' WTP. The effect is more pronounced for younger consumers than elderly consumers. Likely, the taste buds of the younger population are already more accustomed to sweetness in the face of the general nutrition transition. The sweetness of the jackfruit-nut-bars was produced only by adding natural ingredients such as mango. Still, 70% of the participants stated that they would generally buy the product. This finding is welcoming and gives the first indication that industrialized sugar can be substituted by healthier alternatives.

General remarks

Although not explicitly analyzed in this dissertation, consumer demand probably depends on social structures. Elderly women, in particular, are likely to take care of grocery shopping for the entire family and allocate their money accordingly. Thus, if a product designed for more than one person at a time, such as the cowpea leaf soup mix, is not demanded by the whole family, the woman in charge of grocery shopping will likely consider purchasing other products (compare Downs et al. 2022).

Despite the sensitive development of the products focusing on nutrient retention and their market potential, they should not be promoted as panaceas. We highlight that the products can only play a small role in consumption practices and should not be considered as stand-alone solutions for entire diets. No single food can adequately provide humans with all energy requirements and essential nutrients. Therefore, the quality of diets, for example, the incorporation of different food items, remains critical for human health and development. These are important aspects to consider in distribution and marketing. In addition, there is a need to sensitize consumers on healthy quantities of the products to avoid possible overconsumption, especially considering sugar-added processed fruit products. Finally, it is vital to consider the affordability of products, especially for low-resource households. All marketing strategies will only be successful in closing the nutrient gap if the final products are affordable among consumers facing deficiencies. This aspect is currently under analysis by project colleagues.

While the results provide some valuable first insights and can act as starting points for future research, we suggest broadening the scope of research by assessing perceptions of shop-owners in the future. Their perception of the products will play an essential role in shaping distribution success. Furthermore, it might be valuable to investigate perceptions of the products at the

household level to reach consumers who are not encountered at the market but still influence purchasing decisions.

Finally, considering the growing rates of overweight and obesity, assessing sugar substitutes could be the way forward. Although sugar levels of the guava nectar and jackfruit juice were kept to the lowest level accepted by consumers, they still pose a potential health risk if not consumed sensibly. As we could see for the jackfruit-nut-bars that did not include any additional sugar, the sweetness was perceived as just-about-right. It will be interesting to analyze sweetening the guava nectar and jackfruit juice with sugar substitutes or naturally sweet plants available in the research area, such as mangos.

As a last point, we want to elaborate on our experience with analyzing the marketing potential of processed IFV within the FruVaSe project. While we could find some interesting, relevant results for policymakers and rural communities, future projects should consider using a different timing. In our case, the preparation of the studies of this dissertation started simultaneously with product development. Product development, however, takes time, depends on harvest seasons, and needs several trials to develop the most nutritious and sustainable products. Therefore, it is advisable to undertake large-scale market research later. Starting the marketing assessment only when product development has well proceeded could help to ensure that the most valuable products are assessed in the end. Ideally, it could also lead to the products already being officially certified, which would allow trials at higher-end markets, such as supermarkets. It could also help to ensure that sufficient quantities of the products are available for experimental research.

7 Institutional Review Board Statement

The surveys conducted within this dissertation obtained ethical approval from the ethical committee board of the University of Göttingen and the Makerere University School of Health Sciences Institutional Review Board. In addition, research permits were obtained from the National Commission for Science, Technology, and Innovation in Kenya, the Tanzania National Commission for Science and Technology, and the Uganda National Council for Science and Technology, respectively, for the studies conducted in Kenya Tanzania, and Uganda.

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General Appendix

Questionnaires

Note: We programmed the questionnaires presented here with Open Data Kit and used tablet computers for data collection.

Paper 1 and Paper 2

Six enumerators per market.

- ➔ Two recruiting the participants and already checking their qualification
- ➔ Four conducting sensory analysis, experimental auction and questionnaire with and without information

RESPONDENT QUALIFICATION		
1.	Are you responsible for making food purchase decisions in your household?	1 = No 2 = Yes **If 1, the participant is not qualified for this survey, kindly thank him or her for the time and continue with the next participant**
2.	Do you have diabetes?	1 = No 2 = yes 3 = I don't know **If 2 or 3, the participant is not qualified for this survey, kindly thank him or her for the time and continue with the next participant**
3.	Are you allergic or sensitive to any food/ food ingredient?	1 = No 2 = yes 3 = I do not know **If 2 or 3, the participant is not qualified for this survey, kindly thank him or her for the time and continue with the next participant**
4.	Would you be interested in testing…?	1 = No 2 = yes **If 1, the participant is not qualified for this survey, kindly thank him or her for the time and continue with the next participant**
START		
5.	Date	
6.	Participant ID	
7.	What is the name of the enumerator?	
8.	Market	
SENSORY ANALYSIS		
9.	Please select the product that will be shown first to the participant.	
10.	Does the participant receive any additional information about the products (according to the prepared material)?	1 = No 2 = Yes
PLEASE PROVIDE THE PARTICIPANT WITH A SAMPLE OF THE PRODUCT		
11.	How much do you like the color of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it

		4 = Like it 5 = Like it extremely
12.	How much do you like the aroma of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
13.	How much do you like the texture of this product in your mouth?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
14.	How much do you like the taste of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
15.	How much do you generally like this product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
16.	Would you generally buy this product?	1 = no 2 = yes

If applicable, the procedure is repeated for the remaining product(s).

EXPERIMENTAL AUCTION
WITHOUT INFORMATION

Explanation:

- I will show you the two products you just tasted, and I will ask you how much you are willing to pay for each.
- I will ask you to bid for each of the two products and write your two bids down.
- Then you will draw a number from a random distribution. If your bid is higher than the random number, you will buy the product at a price equal to the number you drew. If your bid is lower than the random number, you have no chance of buying the product.

Winning price for the binding product:

- If the bid you offered is higher than or equal to the randomly drawn prize, you win the auction, and you have to buy the product at the price of the random number you picked. Otherwise, you lose the auction and do not purchase the product.
- Kindly note that it will be to your benefit that your bid is the actual amount you are willing to pay for the product. In this kind of auction, if you give a lower bid than your true willingness to pay (for example, you bid 10 KES [6]when your WTP is 40 KES), you might lose an opportunity to buy when you draw 30. If your bid is too high, for example, 1000 KES, and you draw the number 200 KES, you have to buy at that price. At your true WTP, when the number /higher bid than your true value, you are the one who ends up losing.
- Please ask any questions

EXPERIMENTAL AUCTION
WITH INFORMATION

- I will show you two products, one of each of the products you just tasted, in the same order, with additional information (see the end of the questionnaire) and the content of the product: Please take the time to look at the pictures and let me know if you have any questions.

- Now, I will ask you how much you are willing to pay for each product.
- I will ask you to bid for each of the two products and write your two bids down.
- Then you will draw a number from a random distribution. If your bid is higher than the random number, you will buy the product at a price equal to the number you drew. If your bid is lower than the random number, you will not buy the product.

[6] This example was for Kenya, examples in the other countries were in the respective currencies

Winning price for the binding product:

- If the bid you offered is higher than or equal to the randomly drawn prize, you win the auction, and you have to buy the product at the price of the random number you picked. Otherwise, you lose the auction and do not purchase the product.
- Kindly note that it will be to your benefit that your bid is the actual amount you are willing to pay for the product. In this kind of auction, if you give a lower bid than your true willingness to pay (for example, you bid 10 KES when your WTP is 40 KES), you might lose an opportunity to buy when you draw 30. If your bid is too high, for example, 100 KES, and you draw the number 200 KES, you have to buy at that price. At your true WTP, when the number /higher bid than your true value, you are the one who ends up losing.
- Please ask any questions
- The following two questions are to assess if you understand the game correctly

17.	If you state a willingness to pay of 50 KES and pick the number 40 KES from the envelope, what happens next?	1 = You win the auction and pay 50 KES for the product. 2 = You win the auction and pay 40 KES for the product. 3 = You lose the auction and cannot buy the product.
18.	If you state a willingness to pay of 70 KES and pick the number 80 KES from the envelope, what happens next?	1 = You win the auction and pay 70 KES for the product. 2 = You win the auction and pay 80 KES for the product. 3 = You lose the auction and cannot buy the product.
19.	Willingness to pay for the Guava drink in Kenyan Schilling	
20.	Willingness to pay for the cowpea leaf soup in Kenyan Schilling	
21.	Randomly picked number for guava nectar	
22.	Randomly picked number for cowpea leaf soup	
23.	How satisfied are you with the outcome of the lottery for the cowpea leaf soup?	1 = Very dissatisfied 2 = Dissatisfied 3 = Unsure 4 = Satisfied 5 = Very satisfied
24.	How satisfied are you with the outcome of the lottery for the guava drink?	1 = Very dissatisfied 2 = Dissatisfied 3 = Unsure 4 = Satisfied 5 = Very satisfied
	Barriers	
Please indicate your agreement with the following statements when buying a food product. Information about the … is really important to me.		
25.	nutritional value	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
26.	shelf life	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
27.	convenience	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
28.	safety	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree

Health consciousness		
Please indicate your agreement with the following statements.		
29.	I am eating enough fruits for good health.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
30.	I am eating enough vegetables for good health.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
31.	The food I eat is nutritious enough for good health.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
32.	I compare labels to select the most nutritious food.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
Eating behaviour		
Please indicate your agreement with the following statements.		
33.	I feel that preparing food takes too much time.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
34.	I feel that preparing food is too difficult.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
35.	I don't like spending too much time in the kitchen.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
36.	It is important to me that food is easy to prepare.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
37.	I like ready to eat foods.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
38.	I like to take food with me on the go.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
39.	I like to have ample time in the kitchen.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree

40.	I mostly eat at home.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
41.	How important is the price to you when buying a food product?	1 = Not at all important 2 = Not important 3 = Neither important nor unimportant 4 = Important 5 = Very important
42.	How often do you eat fruits?	1 = never 2 = less than once a month 3 = once a month 4 = 2-3 times per month 5 = once a week 6 = 2-3 times per week 7 = 4-6 times per week 8 = daily
43.	How often do you eat vegetables?	1 = never 2 = less than once a month 3 = once a month 4 = 2-3 times per month 5 = once a week 6 = 2-3 times per week 7 = 4-6 times per week 8 = daily
44.	Please name three vegetables that you usually consume	
45.	Why do you consume the aforementioned vegetables?	
46.	Please name three fruits that you usually consume	
47.	Why do you consume the aforementioned vegetables?	
48.	Please name one benefit derived from fruit intake.	
49.	Please name one benefit derived from fruit intake.	
Buying behaviour		
Please indicate your agreement with the following statements.		
50.	I always check prices of foods I purchase, even on small items.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
51.	It is important to me that food has a long shelf life.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
52.	I feel that fruits perish too quickly.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
53.	I feel that vegetables perish too quickly.	1 = Strongly disagree 2 = Disagree

		3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
54.	I notice when products I buy regularly change in price.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
55.	I find the aroma of food products important.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
56.	I feel that seasonality causes shortages in fruits.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
57.	I feel that seasonality causes shortages in vegetables.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
58.	I find the taste of food products important.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
59.	I find the appearance of food products important.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
60.	I choose food products for their taste rather than for their nutritional value.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
61.	I find the texture of food products important.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
Buying barriers		
Now, please indicate your level of importance. How important is it to you that your food		
62.	is in accordance to your religion?	1 = Not at all important 2 = Not important 3 = Neither important nor unimportant 4 = Important 5 = Very important
63.	is in accordance to your tradition?	1 = Not at all important 2 = Not important 3 = Neither important nor unimportant 4 = Important 5 = Very important
64.	is from a well-known processor?	1 = Not at all important 2 = Not important 3 = Neither important nor unimportant 4 = Important 5 = Very important

Food neophobia		
Please indicate your agreement with the following statements.		
65.	I am afraid to eat food I did not eat before.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
66.	I do not trust new food.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
67.	I constantly try new foods.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
68.	I am very particular about the food I eat.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
69.	I will eat almost anything.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
Sociodemographic		
70.	What is your year of birth?	
71.	What is your gender?	1 = male 2 = female
72.	How many people live most of the time in your household?	
73.	What is your level of education?	1 = None 2 = Primary 3 = Secondary 4 = Tertiary 5 = Other
74.	Specify other:	
75.	How many years did you spend schooling?	
76.	What is your marital status?	1 = unmarried 2 = Married 3 = Divorced 4 = Widow 5 = other
77.	If other, please specify	
78.	What is your main occupation?	1 = Farming 2 = Employed 3 = Self-employed 4 = Casual labor 5 = Student 6 = other
79.	What is the distance between your home and this market in kilometres?	
80.	What is the floor of your residence made of?	1 = Earthfloor 2 = Stone 3 = Wood 4 = Cement

		5 = Tile 6 = Other
81.	Specify other:	
82.	What are your walls made of?	1 = Earthwall 2 = Wood 3 = Stone 4 = Brick 5 = Ironsheet 6 = Cement 7 = Other
83.	Specify other:	
84.	What is the roof of your residence made of?	1 = Straw 2 = Bamboo 3 = Cement 4 = Ironsheet 5 = Other
85.	Specify other:	
86.	Does any member of your household own any land that can be used for agricultural purposes?	
87.	Does any member of your household own any livestock herds, or farm animals, or poultry, or fishponds?	
88.	What is the main source of drinking water for you and members of your household?	1 = pipewater or public tap or borehole or dugwell or spring or rainwater 2 = river or stream or dam or lake or pond or canal or truckwater or unprotected dugwell
89.	Does your household have access to a toilet facility?	1 = yes 2 = no
90.	What type of toilet facility do you and your household usually use?	1 = pitlatrine or composting toilet 2 = openpit or bucket or hanging latrine or bush or field or lake
91.	What is your main occupation?	1 = Farming 2 = Employed 3 = Self-employed 4 = Casual labor 5 = Student 6 = other
92.	What is the distance between your home and this market in kilometres?	
93.	What is the floor of your residence made of?	1 = Earthfloor 2 = Stone 3 = Wood 4 = Cement 5 = Tile 6 = Other
94.	Specify other:	
95.	What are your walls made of?	1 = Earthwall 2 = Wood 3 = Stone 4 = Brick 5 = Ironsheet 6 = Cement 7 = Other
96.	Specify other:	
97.	What is the roof of your residence made of?	1 = Straw 2 = Bamboo 3 = Cement 4 = Ironsheet 5 = Other

98.	Specify other:	
99.	Does any member of your household own any land that can be used for agricultural purposes?	1 = No 2 = Yes
100.	Does any member of your household own any livestock herds, or farm animals, or poultry, or fishponds?	1 = No 2 = Yes
101.	What is the main source of drinking water for you and members of your household?	1 = pipewater or public tap or borehole or dugwell or spring or rainwater 2 = river or stream or dam or lake or pond or canal or truckwater or unprotected dugwell
102.	Is there anything else that you would like us to know?	
103.	Please take a picture of the signed consent form	

Paper 3

Six enumerators per market.

- ➔ Two recruiting the participants and already checking their qualification
- ➔ Two questioning sociodemographic characteristics and conducting sensory analysis
- ➔ Two conducting the experimental auction and asking some general questions

Questionnaire:

RESPONDENT QUALIFICATION[7]		
1ST ENUMERATOR THE FIRST ENUMERATOR DOES NOT KNOW THE CONTENTS OF THE PRODUCTS FOR DOUBLE BLIND TESTING.		
1.	What is the name of the enumerator?	
2.	Participant ID	
SOCIODEMOGRAPHIC		
3.	What is your year of birth?	
4.	What is your gender?	1 = male 2 = female
5.	How many people live most of the time in your household?	
6.	What is your level of education?	1 = None 2 = Primary 3 = Secondary 4 = Tertiary **If 1 continue with question 13**
7.	How many years did you spend schooling?	
8.	What is your marital status?	1 = unmarried 2 = Married 3 = Divorced 4 = Widow

[7] Same qualification criteria as in Paper 1&2

		5 = other
9.	If other, please specify	
10.	Are there children between 6 months and 6 years living in this household?	1 = No 2 = Yes **If no continue with question 17**
11.	If yes, how many?	
12.	What is your main occupation?	1 = Farming 2 = Employed 3 = Self-employed 4 = Casual labor 5 = Student 6 = other
13.	If other, please specify	
Landownership in ha		
14.	Total Land	
	Cultivated	
	Uncultivated	
	Maize	
	Millet	
	Other crops	
Livestock ownership		
15.	Cattle	
	Sheep	
	Goat	
	Horse	
	Mule	
	Donkey	
	Chicken	
	Other	
16.	Monthly Cash income	1 = below 222,000 2 = 222,000 –480,000 3 = 481,000 – 832,500 4 = more than 832,500 5 = no information
SENSORY ANALYSIS		
17.	Please select the product that will be shown first to the participant. (Order will be randomized)	1 = Triangle 2 = Square 3 = Circle 4 = Pentagon
PLEASE ASK THE PARTICIPANT TO TEST THE FIRST PRODUCT		
18.	How much do you like the color of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
19.	How much do you like the aroma of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
20.	How much do you like the texture of this product in your mouth?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
21.	How much do you like the taste of the product?	1 = Dislike it extremely 2 = Dislike it

		3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
22.	How much do you generally like this product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
23.	Would you generally buy this product?	1 = no 2 = yes
24.	Please select the product that will be shown second to the participant.	1 = Triangle 2 = Square 3 = Circle 4 = Pentagon
PLEASE ASK THE PARTICIPANT TO TEST THE SECOND PRODUCT		
25.	How much do you like the color of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
26.	How much do you like the aroma of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
27.	How much do you like the texture of this product in your mouth?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
28.	How much do you like the taste of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
29.	How much do you generally like this product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
30.	Would you generally buy this product?	1 = no 2 = yes
31.	Please select the product that will be shown third to the participant.	1 = Triangle 2 = Square 3 = Circle 4 = Pentagon
PLEASE ASK THE PARTICIPANT TO TEST THE THIRD PRODUCT		
32.	How much do you like the color of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
33.	How much do you like the aroma of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
34.	How much do you like the texture of this product in your mouth?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it

		4 = Like it 5 = Like it extremely
35.	How much do you like the taste of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
36.	How much do you generally like this product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
37.	Would you generally buy this product?	1 = no 2 = yes
38.	Please select the product that will be shown fourth to the participant.	1 = Triangle 2 = Square 3 = Circle 4 = Pentagon
PLEASE ASK THE PARTICIPANT TO TEST THE FOURTH PRODUCT		
39.	How much do you like the color of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
40.	How much do you like the aroma of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
41.	How much do you like the texture of this product in your mouth?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
42.	How much do you like the taste of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
43.	How much do you generally like this product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
44.	Would you generally buy this product?	1 = no 2 = yes
45.	Please order the four products from most liked to least liked where 1 = most liked and 4 = least liked	1 = 2 = 3 = 4 =
NOW SEND THE PARTICIPANT TO THE SECOND ENUMERATOR!		
2nd Enumerator		
46.	What is the name of the enumerator?	
47.	Participant ID	
48.	Does the participant receive information about the products (according to the prepared material)?	1 = No 2 = Yes
EXPLANATION – EXPERIMENTAL AUCTION		

➔ I will ask you to make a bid for each of the four products you just tasted ➔ Afterward, we will determine the binding product by drawing a number from this bag. ➔ Then you will draw a number from a random distribution. If your bid is higher than the random number, you will buy the product at a price equal to the number you drew. If your bid is lower than the random number, you will not buy the product. ➔ Explain that it is in the participant's best interest to bid his or her true WTP, give a numerical example. ➔ Kindly note that it will be to your benefit that your bid is the actual amount you are willing to pay for the product. In this kind of auction, if you give a lower bid than your true willingness to pay (for example, you bid 1000 UGX when your WTP is 4000 UGX), you might lose an opportunity to buy when you draw a number of 3000. If your bid is too high, for example, 5000 UGX, and you draw the number 5000, you have to buy at that price. Do you have any questions?		
Now I will ask you questions about the procedure to see if I explained it well.		
49.	If you state a willingness to pay of 3000 UGX and you pick the number 4000 UGX, what happens next?	1 = You buy the product for 3000 UGX using your own money 2 = You buy the product for 4000 UGX using your own money 3 = You cannot buy the product **If 1 or 2, the answer is not correct. Please explain again.**
50.	If you state a willingness to pay of 4000 UGX and you pick the number 3000 UGX, what happens next?	1 = You buy the product for 3000 UGX using your own money 2 = You buy the product for 4000 UGX using your own money 3 = You cannot buy the product. **If 2 or 3, the answer is not correct, please explain again**
51.	What is the maximum number of products you can end up buying?	1 = 4 2 = 3 3 = 2 4 = 1 **If 1,2 or 3, the answer is not correct, please explain again**
52.	Do you have to use your own real money?	1 = No 2 = Yes If 1 the answer is not correct, please explain again
EXPERIMENTAL AUCTION WITHOUT INFORMATION		
I will show you four bags of 60 g product, one of each of the products you just tasted, in the same order, labeled with the same symbol.		
Now please make a bid for all four products.		

	Product code	**Bid in Ugandan Shillings**
53.	Triangle	
54.	Square	
55.	Circle	
56.	Pentagon	

57.	Now please pick a piece of paper to determine the binding product with the binding bid.	1 = Triangle 2 = Square 3 = Circle 4 = Pentagon
Now, you will pick a number from a random distribution to determine the winning price for the binding product. ➔ If the bid you offered is higher than or equal to the randomly drawn price, you win the auction, and you have to buy the product at the price of the random number you picked. Otherwise, you lose the auction and do not purchase the product. ➔ Now let start our bidding		
58.	Random number drawn	
59.	Is the bid stated by the participant higher than the random number?	1 = No 2 = Yes If No, the participant does not buy the product If yes, the participant buys the product at the random number/price

Experimental auction
With information

Explanation:

- I will show you four bags of 60 g product, one of each of the products you just tasted, in the same order, now labeled with the same symbol, and with additional information on the content of the product**: flavored with cowpea leaves or not, type of flour, nutritional content**. Please take the time to read the labels and let me know if you have any questions.
- Now, I will ask you how much you are willing to pay for each product.
- I will ask you to bid for each of the four products and write your four bids down.
- Then you will draw a number from a random distribution. If your bid is higher than the random number, you will buy the product at a price equal to the number you drew. If your bid is lower than the random number, you will not buy the product.

Winning price for the binding product:

- Kindly note that it will be to your benefit that your bid is the actual amount you are willing to pay for the product. In this kind of auction, if you give a lower bid than your true willingness to pay (for example, you bid 1000 UGX when your WTP is 4000 UGX), you might lose an opportunity to buy when you draw a number of 3000. If your bid is too high, for example, 1000 UGX, and you draw the number 2000 UGX, you have to buy at that price.
- Please ask any questions

Now please make a bid for all four products.

	Product code	**Bid in Ugandan Shillings**
60.	Triangle	
61.	Square	
62.	Circle	
63.	Pentagon	

64.	Now please pick a piece of paper to determine the binding product with the binding bid.	1 = Triangle 2 = Square 3 = Circle 4 = Pentagon
Now, you will pick a number from a random distribution to determine the winning price for the binding product. ➔ If the bid you offered is higher than or equal to the randomly drawn price, you win the auction, and you have to buy the product at the price of the random number you picked. Otherwise, you lose the auction and do not purchase the product. ➔ Now let start our bidding		
65.	Random number drawn	
66.	Is the bid stated by the participant higher than the random number?	1 = No 2 = Yes

		If No, the participant does not buy the product If yes, the participant buys the product at the random number/price
DIETARY BEHAVIOUR		
67.	Please indicate the kind of porridge that is currently being consumed most in this household	1 = Single-ingredient flour – millet 2 = Single-ingredient flour – maize 3 = More than one ingredient flour
68.	If more than one ingredient is flour, please specify the other ingredients	
69.	How often do you eat fresh cowpea leaves?	1 = never 2 = less than once a month 3 = once a month 4 = 2-3 times per month 5 = once a week 6 = 2-3 times per week 7 = 4-6 times per week 8 = daily
70.	How often do you eat porridge?	1 = never 2 = less than once a month 3 = once a month 4 = 2-3 times per week 5 = once a week 6 = 2-3 times per week 7 = 4-6 times per week 8 = daily
PLEASE INDICATE YOUR AGREEMENT WITH THE FOLLOWING STATEMENTS.		
71.	I feel that preparing food takes too much time.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
72.	I choose food products rather for their convenience (time to prepare) than their nutritional value.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
73.	I do not like spending too much time in the kitchen.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
74.	Information about convenience (time to prepare) is important to me when buying a food product.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
75.	I always check the prices of foods I purchase, even on small items.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
76.	I notice when products I buy regularly change in price.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree

77.	I am eating enough vegetables for good health.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
78.	I compare labels to select the most nutritious food.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
79.	I always look for food that is quick to prepare when I am at the market.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
80.	I usually look for health information when I buy food products.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
81.	When on the market, I look for food that supports the prevention of diseases.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
82.	I think I should increase my vitamin A intake.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
83.	When on the market, I look for food that supports a strong immune system.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
84.	When on the market, I look for food that supports good eyesight.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
85.	I trust that nutritionally enhanced products are healthier than conventional products	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
86.	I think I should increase my iron intake.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
87.	Please take a picture of the signed consent form	

Paper 4

Six enumerators:

- ➔ Two recruiting the participants and already checking their qualification
- ➔ Four conducting sensory analysis, price sensitivity meter, and questionnaire

RESPONDENT QUALIFICATION[8]		
The enumerator does not know the contents of the products for double-blind testing.		
1.	What is the name of the enumerator?	
2.	Participant ID	
SOCIODEMOGRAPHIC		
3.	What is your year of birth?	
4.	What is your gender?	1 = male 2 = female
5.	How many people live most of the time in your household?	
6.	What is your level of education?	1 = None 2 = Primary 3 = Secondary 4 = Tertiary **If 1 continue with question 13**
7.	How many years did you spend schooling?	
8.	What is your marital status?	1 = unmarried 2 = Married 3 = Divorced 4 = Widow 5 = other
9.	If other, please specify	
10.	What is your main occupation?	1 = Employed 2 = Self-employed 3 = Casual labor 4 = Student 5 = other
11.	If other, please specify	
12.	If student, please specify your subject of studies	
13.	Monthly Cash income	1 = below 222,000 2 = 222,000 –480,000 3 = 481,000 – 832,500 4 = more than 832,500 5 = no information
SENSORY ANALYSIS (DOUBLE-BLIND)		
14.	Please select the product that will be shown first to the participant. (Order will be randomized)	1 = Triangle 2 = Square 3 = Circle 4 = Pentagon
Please ask the participant to test the first product		
15.	How much do you like the color of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it

[8] Same qualification criteria as in Paper 1&2

		4 = Like it 5 = Like it extremely
16.	How much do you like the aroma of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
17.	How much do you like the texture of this product in your mouth?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
18.	How much do you like the taste of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
19.	How would you rate the sweetness of this product?	1 = Much too sweet 2 = Slightly too sweet 3 = Just about right 4 = Somewhat not sweet enough 5 = Very much not sweet enough
20.	How would you rate the fruit flavour of this product?	1 = Much too weak 2 = Somewhat too weak 3 = Just about right 4 = Somewhat too strong 5 = Much too strong
21.	How much do you generally like this product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
22.	Would you generally buy this product?	1 = no 2 = yes
23.	I would recommend this product to family and friends.	1 = Strongly disagree 2 = disagree 3 = neither agree nor disagree 4 = agree 5 = Strongly agree
PRICE SENSITIVITY METER		
24.	At what price would you consider the product too expensive and you would not consider buying it?	
25.	At what price would you consider the product to be so cheap that you would doubt its quality and would not consider buying it?	
26.	At what price would you consider the product to be getting expensive, but you would still consider buying it?	
27.	At what price would you consider the product to be getting cheap, and you would consider it to be a bargain?	
28.	Please select the product that will be shown second to the participant.	1 = Triangle 2 = Square 3 = Circle 4 = Pentagon
Please ask the participant to test the second product.		
29.	How much do you like the color of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it

		5 = Like it extremely
30.	How much do you like the aroma of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
31.	How much do you like the texture of this product in your mouth?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
32.	How much do you like the taste of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
33.	How would you rate the sweetness of this product?	1 = Much too sweet 2 = Slightly too sweet 3 = Just about right 4 = Somewhat not sweet enough 5 = Very much not sweet enough
34.	How would you rate the fruit flavour of this product?	1 = Much too weak 2 = Somewhat too weak 3 = Just about right 4 = Somewhat too strong 5 = Much too strong
35.	How much do you generally like this product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
36.	Would you generally buy this product?	1 = no 2 = yes
37.	Please indicate what applies most to you	1 = I would eat this product every opportunity I had 2 = I would eat this very often 3 = I would frequently eat this 4 = I like this and would eat it now and then 5 = I would eat this if available but would not go out of my way 6 = I do not like it but would eat it on an occasion 7 = I would hardly ever eat this 8 = I would eat this only if there were no other food choices 9 = I would eat this only if I were forced to
38.	I would recommend this product to family and friends.	1 = Strongly disagree 2 = disagree 3 = neither agree nor disagree 4 = agree 5 = Strongly agree
PRICE SENSITIVITY METER		
39.	At what price would you consider the product too expensive and you would not consider buying it?	
40.	At what price would you consider the product to be so cheap that you would doubt its quality and would not consider buying it?	
41.	At what price would you consider the product to be getting expensive, but you would still consider buying it?	

42.	At what price would you consider the product to be getting inexpensive, and you would consider it to be a bargain?	
43.	Please select the product that will be shown third to the participant.	1 = Triangle 2 = Square 3 = Circle 4 = Pentagon
Please ask the participant to test the third product		
44.	How much do you like the color of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
45.	How much do you like the aroma of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
46.	How much do you like the texture of this product in your mouth?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
47.	How much do you like the taste of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
48.	How would you rate the sweetness of this product?	1 = Much too sweet 2 = Slightly too sweet 3 = Just about right 4 = Somewhat not sweet enough 5 = Very much not sweet enough
49.	How would you rate the fruit flavour of this product?	1 = Much too weak 2 = Somewhat too weak 3 = Just about right 4 = Somewhat too strong 5 = Much too strong
50.	How much do you generally like this product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
51.	Would you generally buy this product?	1 = no 2 = yes
52.	Please indicate what applies most to you	1 = I would eat this product every opportunity I had 2 = I would eat this very often 3 = I would frequently eat this 4 = I like this and would eat it now and then 5 = I would eat this if available but would not go out of my way 6 = I do not like it but would eat it on any occasion 7 = I would hardly ever eat this 8 = I would eat this only if there were no other food choices 9 = I would eat this only if I were forced to
53.	I would recommend this product to family and friends.	1 = Strongly disagree 2 = disagree

		3 = neither agree nor disagree 4 = agree 5 = Strongly agree
PRICE SENSITIVITY METER		
54.	At what price would you consider the product too expensive and you would not consider buying it?	
55.	At what price would you consider the product to be so cheap that you would doubt its quality and would not consider buying it?	
56.	At what price would you consider the product to be getting expensive, but you would still consider buying it?	
57.	At what price would you consider the product to be getting inexpensive, and you would consider it to be a bargain?	
58.	Please select the product that will be shown fourth to the participant.	1 = Triangle 2 = Square 3 = Circle 4 = Pentagon
Please ask the participant to test the fourth product.		
59.	How much do you like the color of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
60.	How much do you like the aroma of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
61.	How much do you like the texture of this product in your mouth?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
62.	How much do you like the taste of the product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
63.	How would you rate the sweetness of this product?	1 = Much too sweet 2 = Slightly too sweet 3 = Just about right 4 = Somewhat not sweet enough 5 = Very much not sweet enough
64.	How would you rate the fruit flavour of this product?	1 = Much too weak 2 = Somewhat too weak 3 = Just about right 4 = Somewhat too strong 5 = Much too strong
65.	How much do you generally like this product?	1 = Dislike it extremely 2 = Dislike it 3 = Neither like nor dislike it 4 = Like it 5 = Like it extremely
66.	Would you generally buy this product?	1 = no 2 = yes
67.	Please indicate what applies most to you	1 = I would eat this product every opportunity I had

		2 = I would eat this very often 3 = I would frequently eat this 4 = I like this and would eat it now and then 5 = I would eat this if available but would not go out of my way 6 = I do not like it but would eat it on an occasion 7 = I would hardly ever eat this 8 = I would eat this only if there were no other food choices 9 = I would eat this only if I were forced to
68.	I would recommend this product to family and friends.	1 = Strongly disagree 2 = disagree 3 = neither agree nor disagree 4 = agree 5 = Strongly agree
PRICE SENSITIVITY METER		
69.	At what price would you consider the product too expensive and you would not consider buying it?	
70.	At what price would you consider the product to be so cheap that you would doubt its quality and would not consider buying it?	
71.	At what price would you consider the product to be getting expensive, but you would still consider buying it?	
72.	At what price would you consider the product to be getting inexpensive, and you would consider it to be a bargain?	
73.	Please order the four products from most liked to least liked where 1 = most liked and 4 = least liked	1 = 2 = 3 = 4 =
DIETARY BEHAVIOUR		
74.	I would eat the jackfruit-nut-bar during the following occasions (multiple responses allowed)	1 = At home 2 = At my work place 3 = When travelling short distances, e.g. to work 4 = When travelling long distances, e.g. visiting family/ friends 5 = Together with/ offer visitors 6 = other
75.	Please specify other	
76.	I think this product will be mainly eaten by the following family members (multiple responses allowed)	1 = Children 1-6 years 2 = Children 7 – 12 years 3 = Adolescent 13-17 years 4 = Women 18-45 5 = Women 46 years or older 6 = Men 18 -45 years 7 = Men 46 years or older
77.	How often do you eat fruits?	1 = never 2 = less than once a month 3 = once a month 4 = 2-3 times per month 5 = once a week 6 = 2-3 times per week 7 = 4-6 times per week 8 = daily

		If 1, continue with question 58
78.	How often do you eat fresh jackfruit?	1 = never 2 = less than once a month 3 = once a month 4 = 2-3 times per month 5 = once a week 6 = 2-3 times per week 7 = 4-6 times per week 8 = daily
79.	What is the main reason for you to consume fresh Jackfruits?	
80.	What do you dislike most about Jackfruits?	
81.	How often do you eat processed jackfruit products?	1 = never 2 = less than once a month 3 = once a month 4 = 2-3 times per month 5 = once a week 6 = 2-3 times per week 7 = 4-6 times per week 8 = daily **If 1, continue with question 83**
82.	Please specify the product(s)	
83.	How often do you eat sugared snacks?	1 = never 2 = less than once a month 3 = once a month 4 = 2-3 times per month 5 = once a week 6 = 2-3 times per week 7 = 4-6 times per week 8 = daily
84.	How often do you eat snacks?	1 = never 2 = less than once a month 3 = once a month 4 = 2-3 times per month 5 = once a week 6 = 2-3 times per week 7 = 4-6 times per week 8 = daily
Please indicate your agreement with the following statements.		
85.	I feel that preparing food takes too much time.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
86.	Seasonality causes shortages in Jackfruits.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
87.	I choose food products rather for their convenience (time to prepare) than their nutritional value.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
88.	It is important to me that the food I eat is nutritious enough for good health.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree

89.	I don't like spending too much time in the kitchen.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
90.	Eating snacks between meals helps me to better concentrate.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
91.	I am eating enough fruits for good health.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
92.	I like to take food with me on the go.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
INTENTION TOWARDS SUGAR/ SUGARED SNACKS		
93.	Controlling the intake of sugared snacks prevents tooth decay.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
94.	I control my family's intake of sugared snacks.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
95.	Eating too many sugared snacks can cause severe health problems.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
96.	Controlling the intake of sugared snacks is unnecessary.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
97.	I consume sugared snacks because they are cheap.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
FOOD NEOPHOBIA		
98.	I am afraid to eat food I did not eat before.	1 = Strongly disagree 2 = disagree 3 = neither agree nor disagree 4 = agree 5 = Strongly agree
99.	I do not trust new food.	1 = Strongly disagree 2 = disagree 3 = neither agree nor disagree 4 = agree 5 = Strongly agree
100.	I constantly try new foods.	1 = Strongly disagree 2 = disagree 3 = neither agree nor disagree

		4 = agree 5 = Strongly agree
101.	I am very particular about the food I eat.	1 = Strongly disagree 2 = disagree 3 = neither agree nor disagree 4 = agree 5 = Strongly agree
102.	I eat almost anything.	1 = Strongly disagree 2 = disagree 3 = neither agree nor disagree 4 = agree 5 = Strongly agree
103.	Please take a picture of the signed consent form.	

Information treatments[9]

Guava nectar

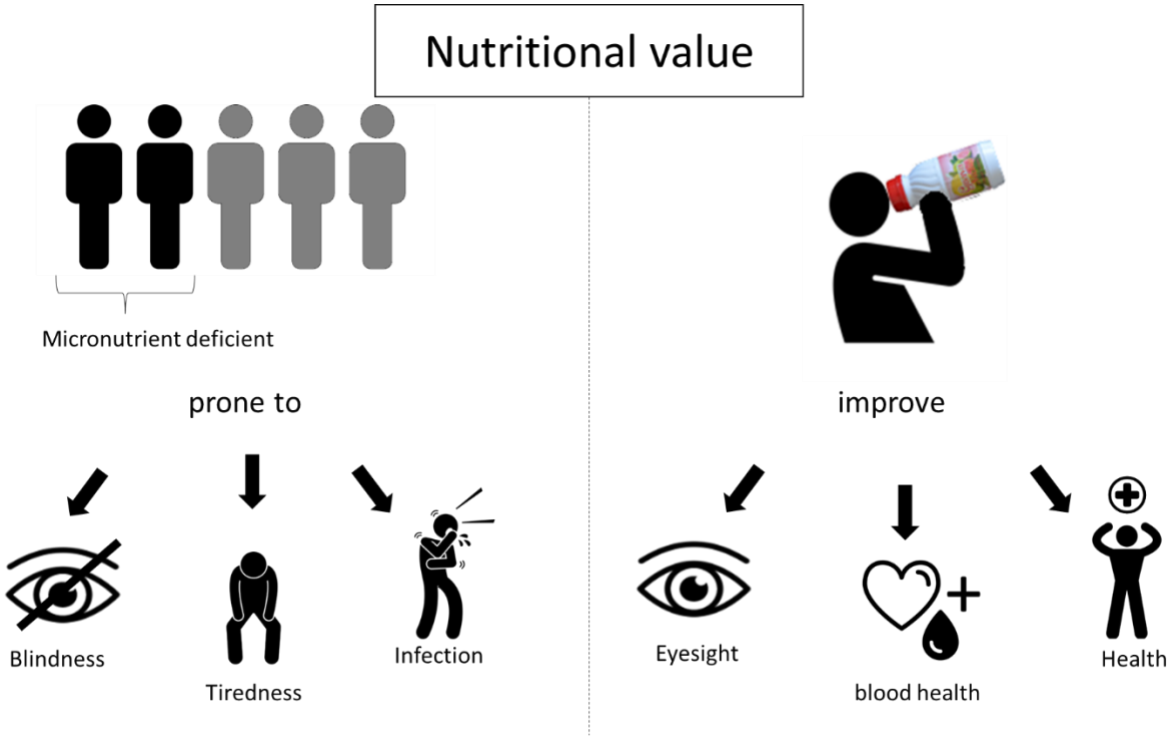
Ingredients:

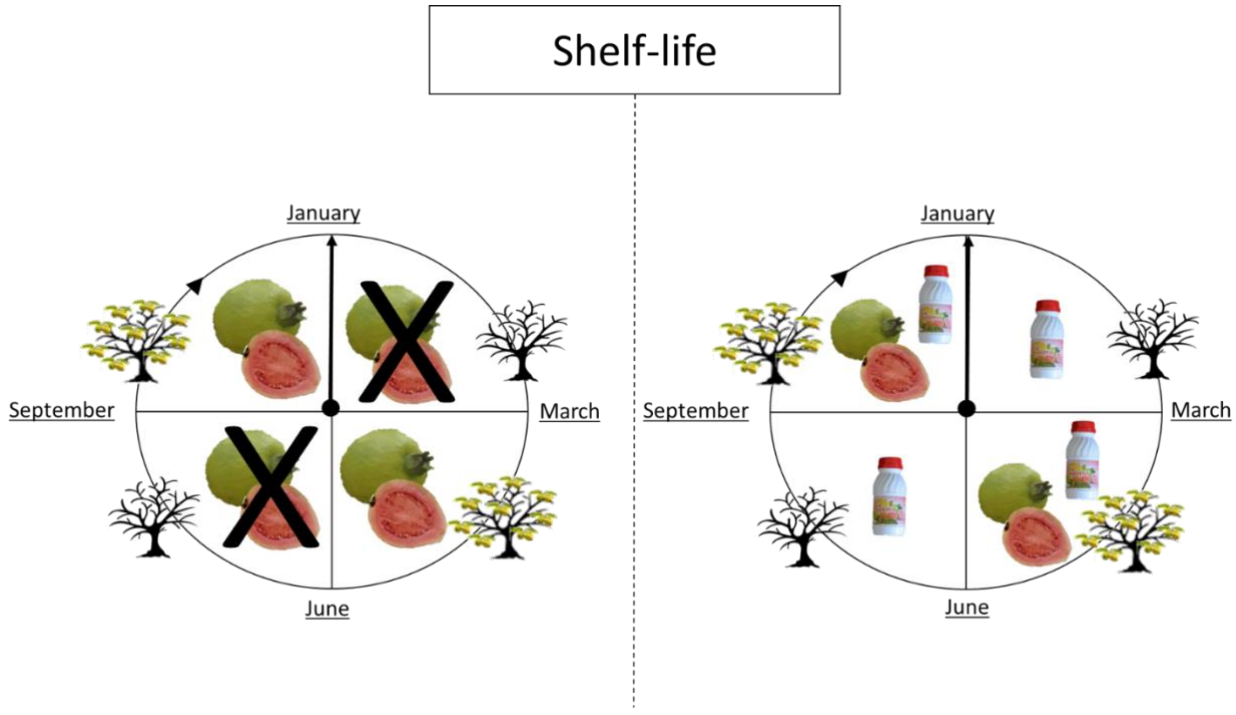
Guava Pulp, Sugar, Citric Acid & Permitted Preservatives

Information

Insufficiency in micronutrients such as vitamin A, vitamin C, or iron has been reported in Kenya. With an insufficient intake of micronutrients, we are more prone to night blindness, tiredness, and infection. Drinking guava nectar can help improve your health because is a good source of β-carotene iron, and zinc. While fresh guava is only available during harvest season, guava nectar has a long shelf life. It is available year-round, independent of the guava growing season. This allows you to consume it even when fresh guavas are not available. The guava nectar can be stored over several months and will remain safe.

[9] All treatments were translated to the respective languages


Nutritional value
Micronutrient deficient
prone to
Blindness
Tiredness
Infection
improve
Eyesight
blood health
Health


Shelf-life
January
September
March
June
January
September
March
June

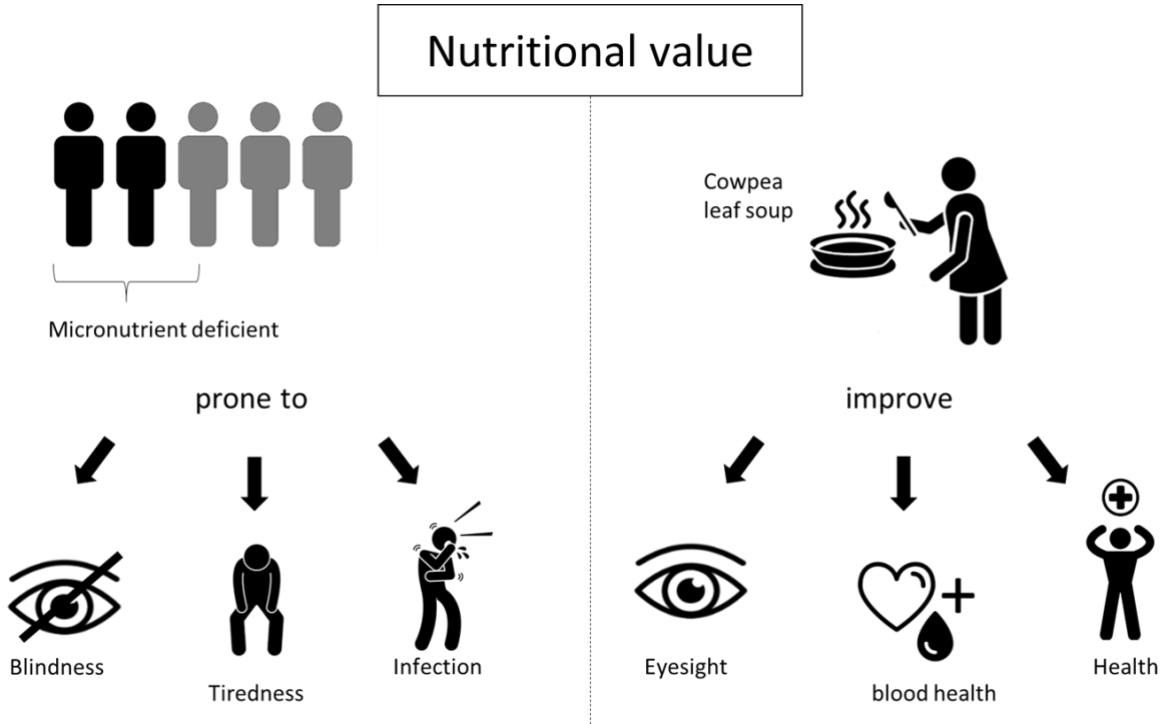
Cowpea leaf soup mix

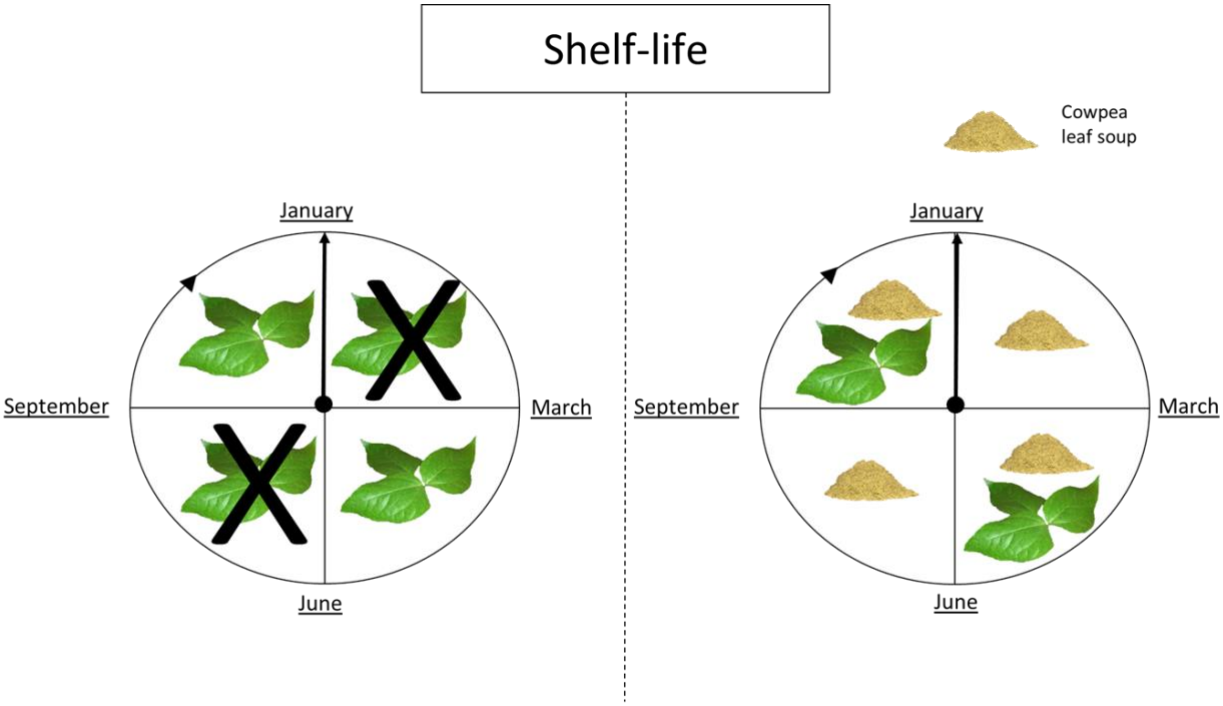
Ingredients:

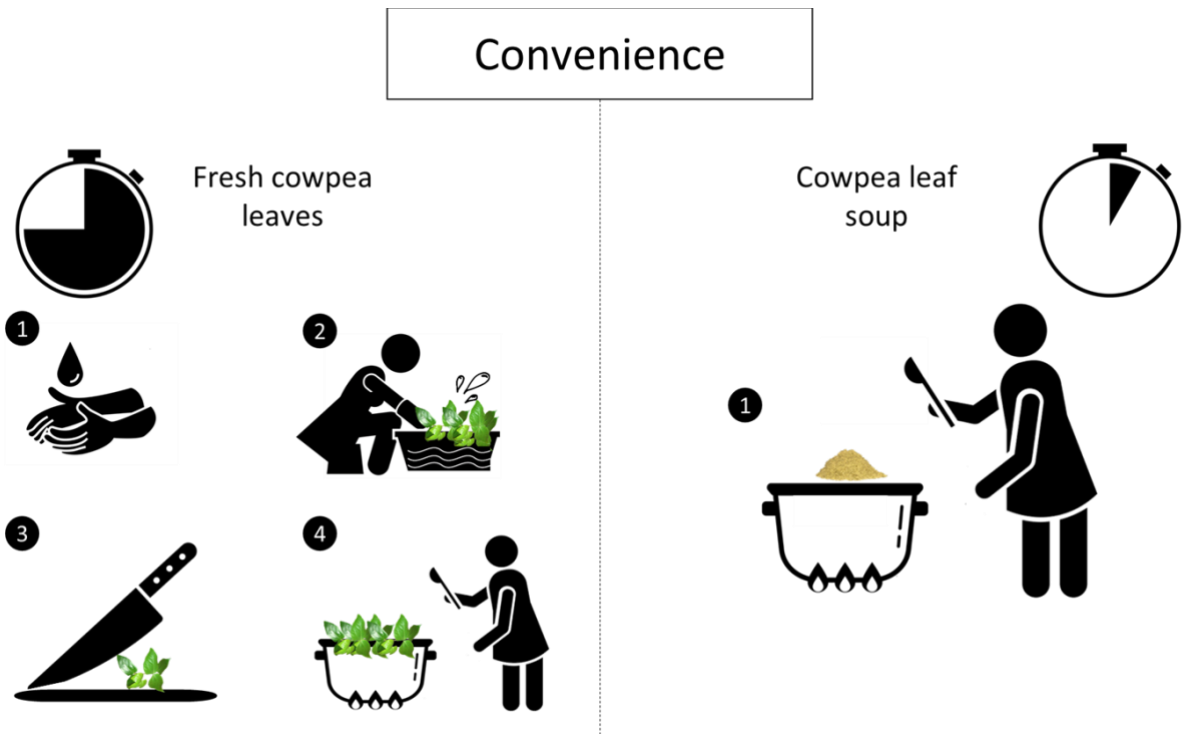
cowpea leaves, the soup contained a mixture of starch, coriander, tomato, onions, vegetable oil, and garlic

Information

Insufficiency in micronutrients such as vitamin A, vitamin C, or iron has been reported in Kenya. With an insufficient intake of micronutrients, we are more prone to night blindness, tiredness, and infection. Eating a cowpea leaf soup mix can help improve your health because it is a good source of β-carotene, iron, and zinc. While fresh cowpea leaves are only available during harvest season, the cowpea leaf soup mix has a long shelf life. It is available year-round, independent of the cowpea growing season. This allows you to consume it even when fresh cowpeas are not available. The cowpea leaf soup mix can be stored over several months and will remain safe. Preparing a cowpea soup mix is easy and fast. Once the water boils, the soup is ready within five minutes. No special cooking skills are needed. This saves time.




Shelf-life
Cowpea leaf soup
January
September
March
June
January
September
March
June


Convenience
Fresh cowpea leaves
Cowpea leaf soup
1
2
3
4
1

African Nightshade relish and dried African nightshade

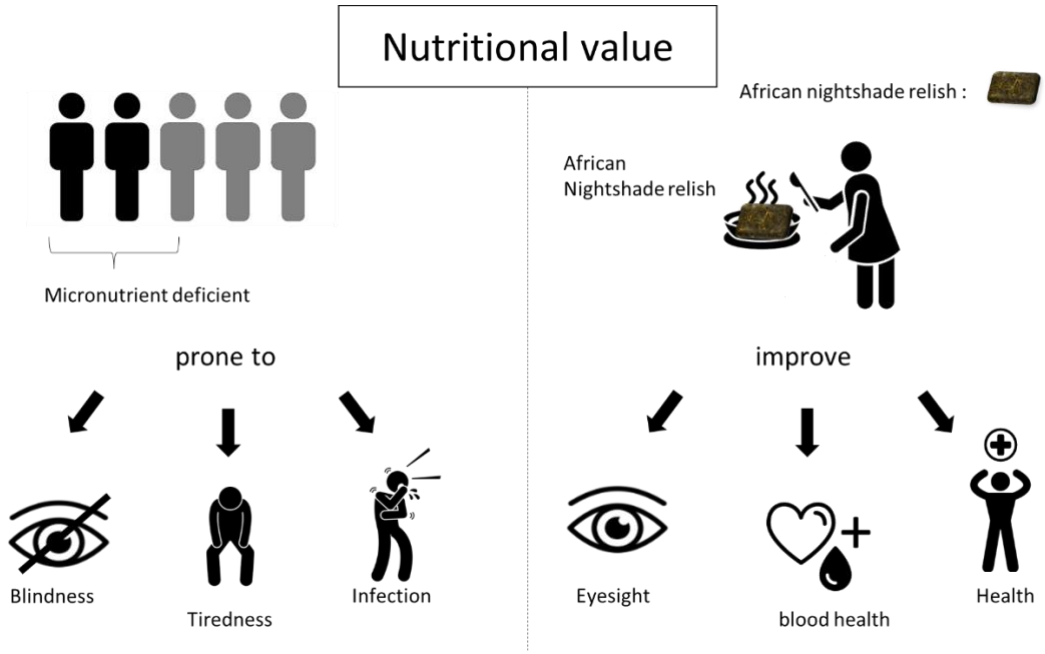
Ingredients:

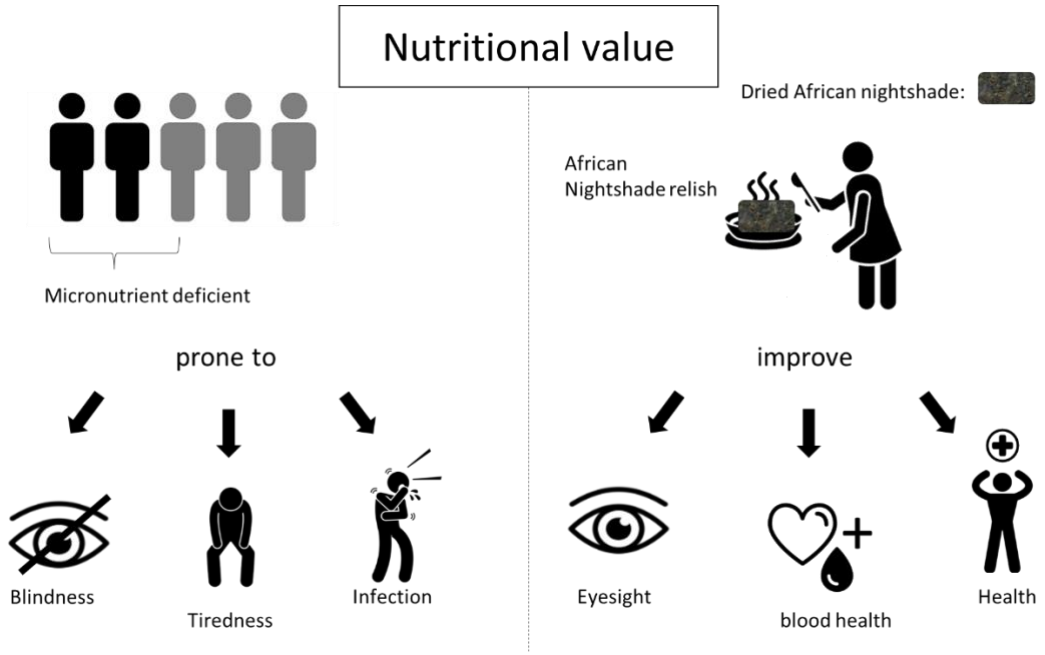
African nightshade relish: African nightshade, Pepper, Turmeric**,** Garlic**,** Cardamon**,** Cooking oil**,** Salt**,** Onions, Carrots**,** Sugar**,** Water, Natural acidic

Dried African nightshade: African nightshade, carrots

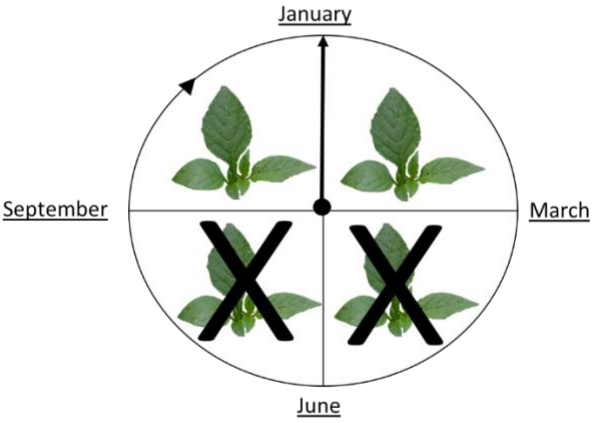
Information

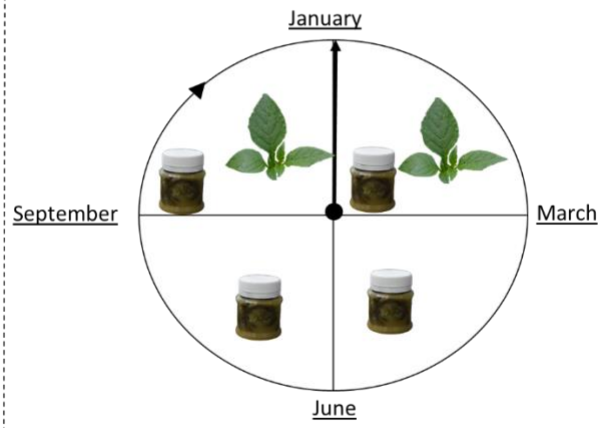
Insufficiency in micronutrients such as vitamin A, vitamin C, or iron has been reported in Tanzania. With an insufficient intake of micronutrients, we are more prone to night blindness, tiredness, and infection. Eating processed African nighshade products can help improve your health because they are a good source of vitamin C and β-carotene. While fresh African nightshade is only available during harvest season, the processed African nightshade products have a long shelf life. It is available year-round, independent of the African nightshade growing season. This allows you to consume it even when fresh African nightshade is not available. The processed African nightshade products can be stored over several months and will remain safe. Preparing processed African nightshade products is easy and fast. No special cooking skills are needed. This saves time.


Nutritional value
African nightshade relish :
African
Nightshade relish
Micronutrient deficient
prone to
improve
Blindness
Tiredness
Infection
Eyesight
blood health
Health

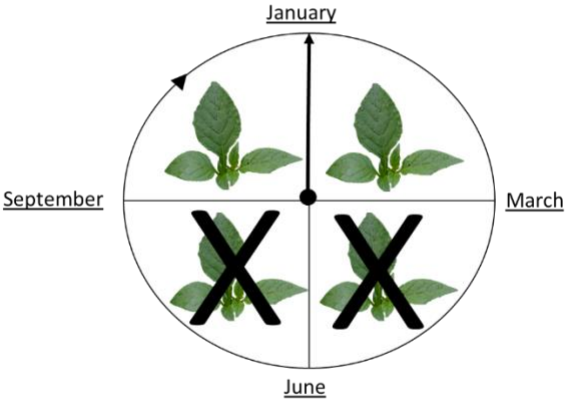

Nutritional value
Dried African nightshade:
African
Nightshade relish
Micronutrient deficient
prone to
improve
Blindness
Tiredness
Infection
Eyesight
blood health
Health

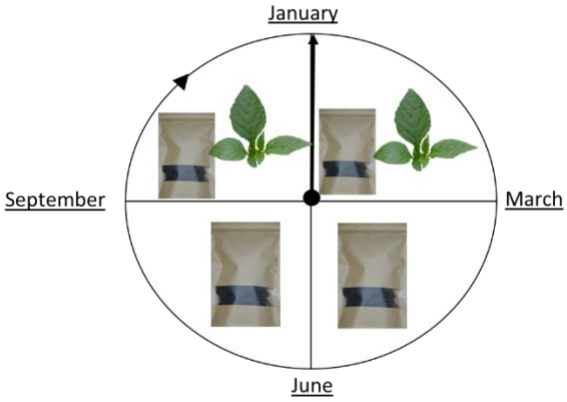
Shelf-life





Shelf-life





Convenience

Fresh African nightshade

African nightshade relish

Convenience

Fresh African nightshade

Dried African Nightshade

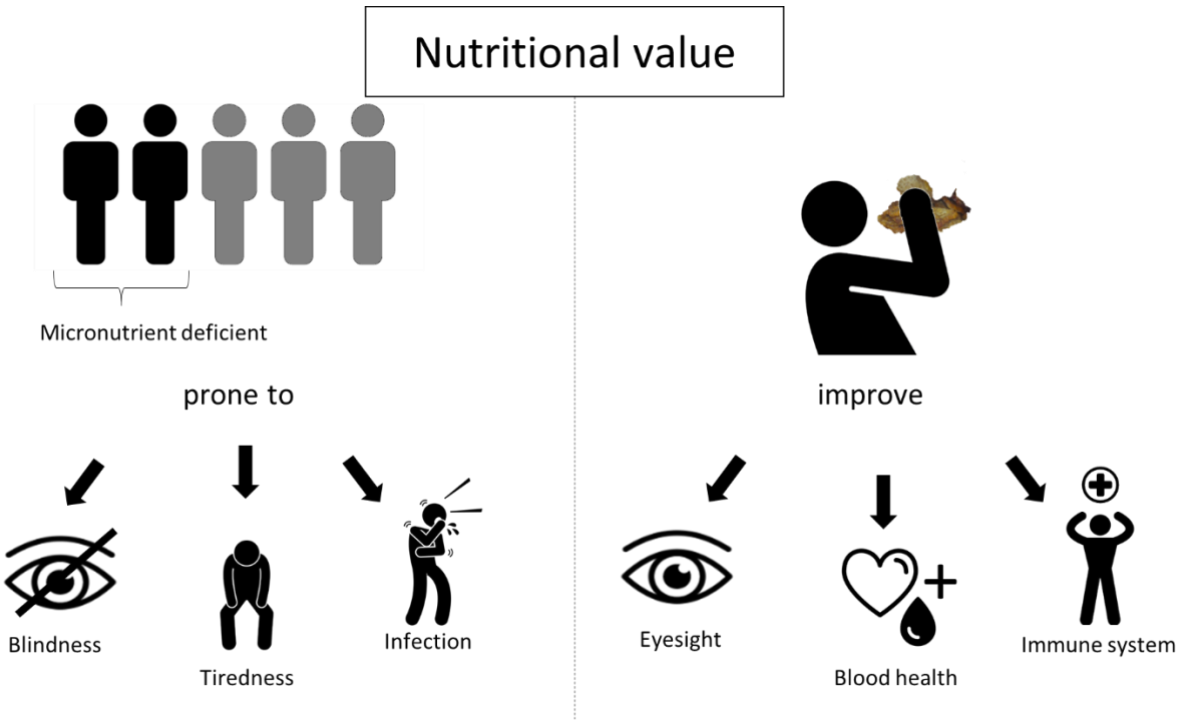
Dried cashew apples

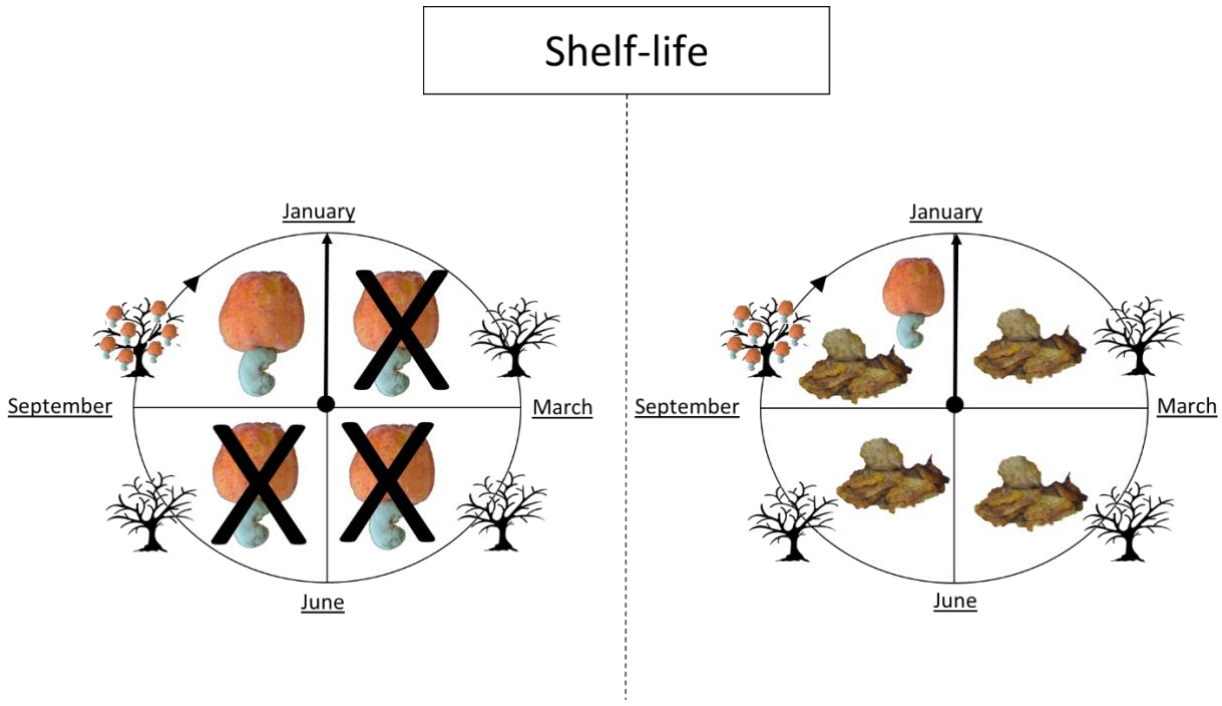
Ingredients:

Cashew apples, sugar

Information

Insufficiency in micronutrients such as vitamin A, vitamin C, or iron has been reported in Tanzania. With an insufficient intake of micronutrients, we are more prone to night blindness, tiredness, and infection. Eating dried cashew apples can help improve your health because it is a good source of β-carotene, iron, and zinc. While fresh cashew apples are only available during harvest season, the dried cashew apples have a long shelf life. They are available year-round, independent of the cashew growing season. This allows you to consume it even when fresh cashew apples are not available. The dried cashew apples can be stored over several months and will remain safe. Dried cashew apples are ready to eat. No special cooking skills are needed. This saves time.


Nutritional value
Micronutrient deficient
prone to
Blindness
Tiredness
Infection
improve
Eyesight
Blood health
Immune system


Shelf-life
January
September
March
June
January
September
March
June

Jackfruit juice

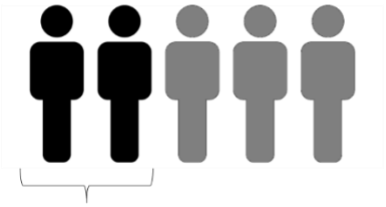
Ingredients:

jackfruit pulp, preservatives, sugar

Information

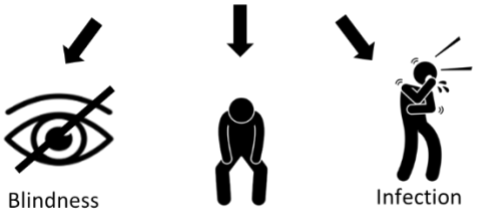
Insufficiency in micronutrients such as vitamin A, vitamin C, or iron has been reported in Uganda. With an insufficient intake of micronutrients, we are more prone to night blindness, tiredness, and infection. Drinking jackfruit juice can help improve your health because it is a good source of vitamin A, iron, and zinc. The jackfruit juice can be stored over several months and will remain safe. The jackfruit juice ready to drink. No special preparation skills are needed. This saves time.

Nutritional value

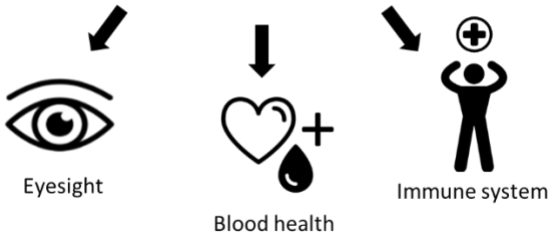


Micronutrient deficient

prone to

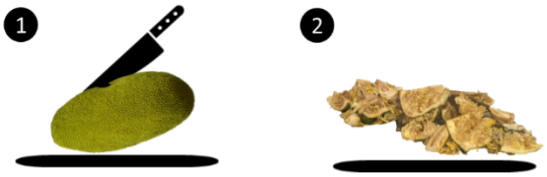


improve

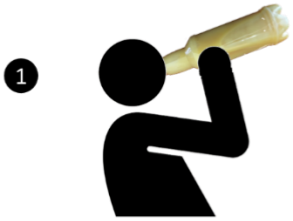


Convenience

Fresh Jackfruit



Jackfruit juice



Declarations

1. I, hereby, declare that this Ph.D. dissertation has not been presented to any other examining body either in its present or a similar form.
   Furthermore, I also affirm that I have not applied for a Ph.D. at any other higher school of education.

Göttingen, ...December 8th,2021.....

.....
(Signature)

Johanna Tepe
.....
(Name in block capitals)

2. I, hereby, solemnly declare that this dissertation was undertaken independently and without any unauthorised aid.

Göttingen, ...December 8th, 2021.....

.....
(Signature)

Johanna Tepe
.....
(Name in block capitals)