CONTRIBUTION OF CASSAVA (*Manihot Esculenta*) TO NUTRITION SECURITY OF CHILDREN 2-5 YEARS IN MIGORI COUNTY

JAMES ODHIAMBO OUMA

(BA. SOCIOLOGY AND POLITICAL SCIENCE)

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Registration Number: A56/7269/2017

College: UNIVERSITY OF NAIROBI

Faculty/School/Institute: COLLEGE OF AGRICULTURE AND VETERINARY SCIENCES

Department: DEPARTMENT OF FOOD SCIENCE NUTRITION AND TECHNOLOGY

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James Odhiambo Ouma

Reg No: A56/7269/2017

This dissertation has been submitted for examination with our approval as university supervisors:

Dr. George O. Abong'

Department of Food Science, Nutrition and Technology

University of Nairobi

Signature..... Date 5/12/2019

Dr. Sophia Ngala

Department of Food Science, Nutrition and Technology

University of Nairobi

Sign..... Date 5/12/2019

DEDICATION

This work is dedicated to my dear wife, Marolene Achieng and children Gloria Akinyi, David Otieno and Isaack Ouma for their endless support in my academic journey.

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OPERATIONAL DEFINATIONS

Household

A household refers to people who live together and share a meal from the same pot at the time of the study (FSAU, 2005).

Nutrient adequacy

This refers to experimentally derived intake that has been taken from a population that appears healthy. No criteria are applied other than absence of deficiency.

Food Security

Food security exists when all people, at all times, have access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 2018).

Nutrition Security

Nutrition security refers to the ability of individuals to obtain and utilize adequate nutrients from the food they consume (Republic of kenya, 2017).

Food Availability

This refers to a situation where people have sufficient quantity of food for consumption.

Food Access

This is the ability to obtain food regularly through own production or purchase.

Utilization

This is refers to ability of people to consume food maximally without wastage, in addition to the body being in a state that is healthy to enable it to metabolize the food consumed.

Ugali

A common dish in Kenya referring to a thick paste made by mixing boiling water and flour.

Kasumba

Cassava leaves preparation that involves boiling then adding milk and salt for consumption.

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
DDS	Dietary Diversity Score
DRC	Democratic Republic of Congo
ENA	Emergency Nutritional Assessment
FAO	Food and Agriculture Organization
WHO	World Health Organization
KDHS	Kenya Demographic and Health Survey
MUAC	Mid-Upper Arm Circumference
WAZ	Weight for Age Z-score
WHZ	Weight for Height Z-score
HAZ	Height for Age Z-score
HH	Household head
USD	United states Dollar
SD	Standard deviation
SPSS	Statistical Package for Social Scientists
HCN	Hydro Cyanide
RDA	Recommended Dietary allowance
UNICEF	United Nations International Children's Emergency Fund.
SMART	Self-Monitoring, Analysis and Reporting Technology

ABSTRACT

Malnutrition is linked to over three quarter of morbidity cases among children less than five years globally. In Kenya, it remains a major health problem. Its prevalence among pre and school going children raise an alarm for the need for nutritional surveillance or nutritional intervention programs. The main form of malnutrition in Kenya is protein-energy malnutrition. To solve this problem, many African countries, Kenya included, have embarked on promoting cassava production and utilization. This is because of its ability to grow in harsh environmental conditions there by seen as the best alternative food security crop. However, the main problem is that areas with high cassava consumption continue to record high rates of under-five malnutrition. The study aimed at establishing the contribution of cassava to nutrient adequacy of children 2-5 years in Migori County of Kenya.

A cross sectional survey was carried out in Migori County, concentrating in Uriri and Nyatike Sub Counties where cassava is predominantly grown. Through Multi-stage sampling, 9 villages were identified of which 253 households were randomly selected. Data was collected on the households' demographic characteristics, economic activities and cassava production and consumption practices. The dietary diversity data of 2-5 year old children was also collected, their morbidity experiences and anthropometry measurements recorded taking note of their weight, height and mid upper arm circumference (MUAC). Seven cassava flour samples of different cassava varieties grown in the area were obtained from farmers and analysis done for moisture, cyanide and protein contents on flour and cooked ugali product.

The main tools used for collecting data were semi-structured questionnaire that included the ones for food frequency, dietary diversity score and 24hr recall dietary intake. Analysis of results was done using Genstat, Nutri-Survey, Statistical package for social scientists (SPSS) and ENA for SMART.

The results indicated that the study population comprised of 1203 people of whom 48.2% were male and 51.8% women. The average household size was 4 and the mean age of the study children was 43 months with a range of 24 -59 months.

The study showed that 72.1% of the households lived on average income of below 50 US dollars per month; however they highly depended on sale of farm and livestock produce (99.1%) for their daily economic sustainability. Ninety four percent of the households consumed cassava of which 88.4% produced cassava for their own consumption from their farms. The most preferred cassava variety was Rateng'. Cassava consumption provided to the children 30% of energy and 0.69% of protein of their daily nutrient requirement. There was a positive correlation (0.32) between cyanide and moisture contents whereas a negative correlation (-0.31) between cyanide and protein contents. The main cassava products consumed were porridge and hard porridge (*ugali*). Majority of the households (95%) neither consumed nor were aware that cassava leaves are being consumed.

It was established that the cyanide levels on average on dry flours was 53.23mg/kg while on ready to eat cooked *ugali* was 13.44mg/kg. This exceeded the WHO recommended levels of 10mg/kg of bitter cassava. The mean dietary diversity score (DDS) for children was 4±1. The overconsumption of cassava was insignificant predictor of the dietary diversity score ($p>0.05$). There was a significant ($p<0.05$) positive correlation (0.17) between household size and DDS score of the children. The nutritional status of the children indicated that over 85% of the children had normal weight for age, height for age and weight for height. However, 13.4% of the children were wasted of which 6.3% were severely wasted. High prevalence of malaria (54%) and diarrhea prior to the study could have been a major contributor.

Cassava contributed positively to the energy intake of 2-5years children and additional intake of other protein rich food products that reduced cases of malnutrition. Cassava farming

households in the study area require support to promote low cyanide varieties in order to reduce the anti- nutrient intake.

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND INFORMATION

In the world, Cassava (*Manihot esculenta crantz*) is ranked the fifth most important food crop after wheat, rice, maize and potatoes (Prakash, 2011). It forms the primary carbohydrate source for over 800 million people across the tropics. Genetic analysis has revealed that it was domesticated from a wild ancestor in western Brazil around 10,000 years ago (Rival et al., 2008). In Africa, cassava was introduce around 16th century by the Portuguese traders from Brazil (Ezedinma, 2017). Since 1980s, Nigeria has remained the global cassava producer with 45 million metric tons annually (Dada, 2016).

The utilization of cassava varies within different parts of the world. In Africa 88% of the population consume it as human food while in America and other European countries, one-third use it as animal feed (Westby, 2009). The major cooking and consumption of cassava varies among communities. Fresh cassava roots are consumed as boiled and fried as crisps or chips. Cassava leaves are consumed as boiled, fried vegetables or cooked as an ingredient in a soup. In some rural households, the roots and leaves are both fed to livestock. The highly processed and marketed form of cassava is dried chips and flour used for cooking porridge and stiff porridge (ugali) (Abass, 2008).

The roots are the most consumed and provide fiber, Thiamine, Phosphorus, Calcium and Vitamin C among other nutrients. Cassava is known to help reduce inflammation disorders, risks of obesity and Type 2 diabetes (Westby, 2009). The leaves are also food source and acts as a backup when other leafy vegetables are not available. The leaves are rich in vitamin A and protein though low in calories (Wargiono, 2002). During food shortages, cassava has predominantly been used and contributed greatly as food security crop to households (Guira et al., 2017). This has been promoted by its ability to survive in marginal unfertile soils, has

diverse usage and low farming inputs compared to rice and maize (Donkor et al., 2017) It has played a role in increasing income to families; reduce poverty levels in both rural and urban dwellings and help close food gaps. Kenyan's annual cassava fresh root production is estimated at 662, 405 tones, against an annual demand of 301, 200 tons of dried cassava and 120, 4800 metric tons of fresh roots (FAO, 2014).This shows that there is need to promote further production and utilization of cassava.

In Kenya, malnutrition has remained a major challenge to the growth and development of children (GOK/UNICEF, 1998). Malnutrition is described as the percentage of children under age 5 whose weight for age is more than two standards deviation below the median for the international reference population ages 0-59 months (Manda et al., 2016). Nearly 73000 children in Kenya are severely malnourished and at risk of dying from nutrient deficient malnutrition (WHO, 2006). To address this problem, cassava (which has been considered for a long time to be a low income people food) has received great support in East Africa; Kenya included (Gibson, 2005).

1.2 STATEMENT OF THE PROBLEM

Cassava has existed for many years as a food security crop and its consumption in certain parts of the country is documented. It's an energy dense crop but lacks other essential nutrients like protein, zinc, iron and vitamin A. This would thereby promote protein energy malnutrition hence calls for the study. As documented, areas with high cassava consumption continue to record high rates of under-five malnutrition (Stephenson et al., 2010). Migori County was suitable for the study since majority of the households grow and consume cassava. Beside the stated problem few studies have been carried out to established cassavas contribution to the nutritional status of children less than 5 years. According to World Health Organization (2018), 52 million children under 5 years of age are wasted, 17 million are

severely wasted and 155 million are stunted, while 41 million are overweight or obese globally. The 2-5 years would be important to this study since they solely depend on food provided to them by their care givers.

1.3 JUSTIFICATION

The main contributor of the global burden of disease is malnutrition and in adequate diet (Forouzanfar et al. 2015). It is estimated that 45% of deaths of children under five years are linked to malnutrition (Black et al.2013). Globally, 26% of children under five years are stunted, 16% underweight and 8% wasted (UNICEF/ WHO/World bank et al., 2016). Among these, Africa and Asia account for 90% of the children stunted and 75% of those wasted. According to the global nutrition report (2015), ending malnutrition depend on the choices we make or fail to make because malnutrition global calamity is inevitable. In Kenya, malnutrition remains a major health concern and besides government initiatives to curb down the vise, a lot need to be done.

As part of intervention for food security, cassava crop has been identified as the ideal crop to grow in Africa. In Kenya it's the second most important food crop and highly produced and utilized in coastal, eastern and western regions, Migori County included (Githunguri et al., 2017). It's an energy dense crop but lacks other essential nutrients like protein, zinc, iron and vitamin A (Carlos, 2019). This would thereby promote protein energy malnutrition hence calls for the study. The study also seeks to discover the diversity of diets among cassava consumers, especially children 2-5 years as well as their nutritional status so that to provide proper nutritional guidelines to the consuming households and help the County health and nutritional officers in planning on important areas in their sector for the households.

The information obtained from this study would be important to the local community households and health service providers to relate cassava consumption and its impact to the health of their children. Researchers and government would benefit by getting information on cassava consumption patterns and thereby identify gaps to work on. The study will also help the County government to plan on food security and general health matters in the area.

1.4 AIM

The aim of this study is to improve the utilization of cassava as a food and nutrition security crop in Western Kenya.

1.5 PURPOSE

The purpose of the study is to determine the contribution of cassava to nutrition adequacy, dietary diversity and nutritional status of children 2-5 years in Migori County.

1.6 STUDY OBJECTIVES

The overall objective of this study was to establish the contribution of cassava crop to the nutrient adequacy of children 2-5 years in Migori County.

1.6.1 Specific objectives

1. To describe the socio-demographic characteristics of the study population.
2. To determine the dietary diversity of the diets of children 2-5 years in Migori County.
3. To determine the amount of dietary energy and protein obtained from cassava consumption by the children 2-5 years in the study County.

4. To determine the protein and cyanide content of cassava flour and product of highly consumed varieties in Migori County
5. To assess nutritional status and morbidity pattern of children 2-5 years in the study area

1.7 RESAERCH QUESTIONS

1. What are the socio demographic characteristic of the households consuming cassava in Migori County?

2. What is the prevalence of cassava consumption among children 2-5 years in Migori County?

3. What is the association between dietary diversity of the diets children aged 2-5 years and the nutritional status in the study population of Migori County?

4. What is the protein and cyanide content of raw cassava flour and cooked cassava Ugali consumed in Migori County?

5. What is the nutritional status and morbidity pattern of children under 5 years in Migori County?

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

Cassava is an old age root and tuber crop known by many people. It has been grown and used in various forms such as food, animal feed, and beverages. Its production currently has expanded to more than 100 countries with Africa, Tropical America, and Asia being the greatest beneficiaries (Hillocks, 2002). Cassava fulfills the caloric daily intake demand of people living in these regions. Its adaptability to harsh environmental conditions, ability to produce high yields in poor soils under minimum inputs makes it a food security crop (Ezedinma, 2017). It's highly consumed in Central, Western and Eastern Africa. Traditionally, Cassava was identified as a hunger reserve crop but with current research and adoption of high yielding varieties and the resultant increase in yield the status has changed (Montagnac et al., 2009). It has evolved as a cash produce crop and raw material in the manufacturing of variety of starchy products. Therefore its production and utilization must be given attention in food policy.

2.2 CASSAVA PRODUCTION AND CONSUMPTION IN AFRICA

The spread of cassava to Africa began in the 19th century through the Portuguese navigator (Fasuyi, 2005). It latter spread to East Africa through Madagascar and Zanzibar (Nweke et al., 2002).The robust spread happened in the 20th century and was influenced by colonial powers as a reserve against hunger and the ability of the crop to survive locust attack.

The largest producer in Africa and even the world is Nigeria followed by Thailand and Indonesia (Adeyemo et al., 2019). Challenges realized in the 1990's such as declining soil fertility and increased cost of inorganic fertilizers have promoted cassava production in Africa. Cassava has other extra ordinary characteristics since it's resistant to crop pests and diseases, its response to famine, hunger and drought makes it considered as a food security

crop. Assessment of cassava production in Africa is challenging because it is primarily grown under subsistence conditions, has an irregular harvesting pattern, and estimates on yield and production vary (FAO, 2012; Minot, 2010). Yield estimates obtained from a sample of major cassava producing areas (COSCA) were consistently higher than FAO estimates based on the national agricultural census (Nweke et al., 2004).

2.2.1 Cassava production and utilization in Kenya

Cassava is grown nearly in all areas of Kenya. However, high production is realized in Western, Coastal and semi-arid (Eastern) regions. The major traditional cooking and consumption pattern in Kenya households is boiling of fresh roots and roasting (Muinga et al., 2010). In Western and Nyanza provinces, processing of Cassava roots involve peeling, grating into smaller pieces, fermenting, sun drying and then milling. The flour obtained is then used to cook ugali or porridge. Cassava production in Kenya is mainly used for human consumption after being processed into various forms, surplus are used for animal feeds or processed for starch. (Githunguri, 1995)

2.3 NUTRITIVE VALUE OF CASSAVA

Cassava roots are the most highly consumed part of the cassava plant in developing countries. A mature cassava plant comprises of 50% leaves and 60% roots which are both nutritionally valuable (Teme& Instaladio, 2004)

Composition of cassava nutrients varies and depends on factors such as geographical locations, cropping systems, variety, plant age, and environmental conditions (Montagnac et al., 2009). The energy reserve of the roots provides carbohydrate content of 80 to 90% dry matter(DM) and of between 32 to 35% on fresh weight(FW) basis (Montagnac et al., 2009).

Cassava leaves are very essential, they are rich sources of vitamin B1, B2 and C, minerals, proteins and carotenoids (Montagnac et al., 2009).

The proximate, vitamins and mineral composition of cassava leaves and roots are indicated in Table 1, while Table 2 compares the composition of raw cassava nutrients to other staple food crops.

Table 1: Proximate minerals and vitamins composition of cassava leaves and roots

	Cassava roots (100g)	Cassava leaves (100g)
Energy in kcal	110 -149	91
Moisture (g)	45.9 -85.3	64.8 -88.6
Dry matter (g)	29.8 -39.3	19 -28.3
Protein (g)	0.3 -3.5	4.0 -18.0
Lipid (g)	0.03 -0.5	0.2 -2.9
Carbohydrate, total (g)	25.3 -35.7	7 -18.3
Dietary fiber (g)	0.1 -3.7	0.5 -10.0
Ash[e] (g)	0.4 -1.7	0.7 -4.5
Thiamin (mg)	0.03 -0.28	0.06 -0.31
Riboflavin (mg)	0.03-0.06	0.21 -0.74
Niacin (mg)	0.6 -1.09	1.3 -2.8
Ascorbic acid (mg)	14.9 -50	60 -370
Vitamin A (μg)	5.0 -35.0	8300 -11800
Calcium (mg)	19 -176	34 -708
Phosphorus, total (mg)	6 -152	27 -211
Ca/P	1.6 -5.48	2.5
Iron (mg)	0.3 -14.0	0.4 -8.3
Potassium (%)	0.25 - 0.72	0.35 -1.23
Magnesium (%)	0.03 - 0.08	0.12 - 0.42
Copper (ppm)	2.00 - 6.00	3.00 - 12.0
Zinc (ppm)	14.00 - 41.00	71.0 - 249.0
Sodium (ppm)	76.00 - 213.00	51.0 - 177.0
Manganese (ppm)	3.00 - 10.00	72.0 -252.0

Source, USDA National Nutrient database for standard references (http://www.nal.usda.gov/fnic/foodcomp/search/). Nutrient values and weights represent edible portion. Montagnac et al., 2009

Table 2: Nutritional composition of different foods (g/100 g) for compared to cassava root

Food	Water (g)	Energy (kcal)	Protein (g)	Total lipid (g)	Ash (g)	Carbohydrate by difference (g)	Dietary fiber (g)	Sugars (g)
Cassava, raw root	59.68	160	1.36	0.28	0.62	38.06	1.8	1.7
Potato, raw	79.34	77	2.02	0.09	1.08	15.47	2.2	0.78
Cereals								
Wheat flour, unenriched	11.92	364	10.33	0.98	0.47	76.31	2.7	0.27
Bread, wheat	35.74	266	10.91	3.64	2.2	47.51	3.6	5.75
Rice, white, unenriched	12.89	360	6.61	0.58	0.58	79.34	—	—
Corn, sweet, white, raw	75.96	86	3.22	1.18	0.62	19.02	2.7	3.22
Corn, yellow	10.37	365	9.42	4.74	1.2	74.26	7.3	0.64
Sorghum	9.2	339	11.3	3.3	1.57	74.63	6.3	—
Vegetables (raw)								
Green beans	90.27	31	1.82	0.12	0.66	7.13	3.4	1.4
Carrots	88.29	41	0.93	0.24	0.97	9.58	2.8	4.74
Spinach	94	14	1.5	0.2	1.8	2.5	—	—
Lettuce, green leaf	95.07	15	1.36	0.15	0.62	2.79	1.3	0.78
Soybeans, green	67.5	147	12.95	6.8	1.7	11.05	4.2	—
Animal produce								
Raw egg (white)	87.57	52	10.9	0.17	0.63	0.73	0	0.71
Cheese, Cheddar	36.75	403	24.9	33.14	3.93	1.28	0	0.52
Milk (whole)	88.32	60	3.22	3.25	0.69	4.52	0	5.26

Source, USDA National Nutrient database for standard references (http://www.nal.usda.gov/fnic/foodcomp/search/). Nutrient values and weights represent edible portion. Montagnac et al., 2009

2.4 CYANIDE IN CASSAVA

Cassava root and leaves contains cyanogenic glucosides. This are hydrolyzed by an enzyme called linamarase to produce cyanohydrins which breakdown to toxic cyanide (Njoku et al., 2018). High amount of cyanide poison is found in bitter cassava of which when ingested in large amount may lead to death and irreversible paralysis of legs that mainly affect children and young women (j.Howard, 2011).

The leaves and roots of Cassava contain cynogenic glucosides. These are hydrolyzed by an enzyme called linamarase resulting to cynohydrins which are further broken down to toxic cyanides (Lambert et al., 2015). The cyanogenic glucocides in the roots and leaves are dangerous to human health since their intoxication may lead to death. They also exacerbate goiter, occurrence of tropical ataxic neuropathy and stunting of children (Oloya et al., 2017). It also causes a disease called Konzo which is an irreversible paralysis of the legs among children. This disease is commonly found in Cameroon, Mozambique, Tanzania, DR Congo, Central Africa Republic and other tropical countries. Several attempts have been made to alleviate cassava cyanide toxicity that includes developing information network and distribution of picrate kits used to measure Urinary thiocyanate and total cyanide in cassava (Nhassico, 2008). The various traditional processing methods undertaken have shown great impact in reducing cyanide. Drying is the most ubiquitous processing operation in many tropical countries (Baskin et al., 2008). Fermentation, boiling, and ensiling are efficient techniques for removing cyanide from cassava peels (G padmaja, 2009).

2.5 MALNUTRITION AMONG CHILDREN BELOW 5 YEARS

Challenges of malnutrition in Kenya have contributed highly to unhealthy growth of the nation. Set millennium goals and vision 2030 cannot be achieved if the nation is hungry hence an indication of human rights violation (Mohajan, 2014).

Children under 5 years and women are the most affected by micronutrient deficiencies. Over 10million people in Kenya are chronically food insecure with malnutrition being the single greatest contributor (Mohajan, 2014). Poor nutrition in infancy and early childhood promotes the risks of infant child mortality and morbidity; diminished cognitive and physical development marked by poor performance in school and also impacts on productivity later in life (Mohajan, 2014).

A survey done in Kenya in 2011 by national micronutrient shows that the most common deficiencies include; iron deficiency (anemia 6–72 month olds 61.4% , pregnant women 41.6%) and vitamin A deficiency (under-5, 52.6%). The other major ones are zinc deficiency (mothers 68.3% and children under-5, 82.3%) and iodine (26.8%) deficiency disorders (KNMS, 2011) Some elementary causes of malnutrition are inadequate food intake and disease while the underlying causes include household food insecurity, poor maternal /child care practices and inadequate health services.

2.5.1 Impact of climate change in malnutrition

The adverse effects of climate change to Agriculture are unbelievable. In the past 40 years, Agricultural production has declined and this trend is continuing (Mupakati et al., 2007) . The rain patterns have changed due to the issues of global warming. The impacts of drought has resulted to extreme precipitation of soil hence reparations on food security globally (Thompson et al., 2016). Food security problems arises due to supply and demand related

pressures, that includes markets globalization, economic conditions, food safety and quality, change in land use, demographic change, and disease and poverty food (Hatfield & Takle, 2014) There is critical proof that temperature increases in the period between 1980-2008 have resulted to average Maize and Wheat global yield reductions to 3.8% and 5.5% respectively in comparison to cases where climate did not change (Lobell, 2007)

2.6 CASSAVA CONSUMPTION AND NUTRIENT ADEQUECY

Cassava (Manihot esculenta Crantz) plays a great role in the diets of many people in relation to energy provision. Over 500million people in more than 80 countries found in Africa, Latin America, Asia, Oceania areas depend on cassava as a major source of energy (Mupakati et al., 2007). It is grown in over 39 countries and in terms of food produced in Sub-Saharan Africa, cassava accounts for a large proportion (Meridian Institute, 2002). In Kenya it is the second most consumed root crop after irish potatoes (Githunguri, 2017). The roots harvesting can be prolonged in the ground until needed hence considered a multiple year crop suitable for food security. (El-sharkawy, 2004; Gbadegesin et al., 2013). However, ‘a less recognized threat is the poor nutrient quality, which because of high levels of consumption of this staple carbohydrate, threatens a large proportion of the population with malnutrition and poor quality of life’ (Salvador., 2014).

2.7 MAJOR TRADITIONAL CASSAVA FOODS

The cassava root especially in Sub-Saharan Africa has significantly contributed to food security, employment and income generation. Cassava roots have high moisture content, these makes them prone to post harvest deterioration accelerated by microbial and biochemical changes in the product. ‘Processing is used to extend the shelf life, facilitate

transport and, most importantly, detoxify the roots by removing the inherent cyanogen's (Abass et al., 2017).The most known Traditional products includes;

2.7.1. Gari

Gari preparation undergoes various processes. It begins by peeling, then washing and finally grating the cassava roots. The resultant pulp is then put in porous manila sucks, heavy objects are used to press water from the pulp for at least three days (Kouakou et al., 2016). Pulverization and sieving is then done to the dewatered fermented pulp. It's then toasted in a pan. "The grating, effluent expressing, pulverization, toasting and the addition of palm oil are adequate to reduce cyanogens to a safe level" (Kouakou et al., 2016). The obtained product has a sour taste as a result of fermentation of which varies according to consumer preference. Gari always has a longer shelf life if stored under dry environment, its known not to be attacked by weevils as is maize (Flibert et al., 2016).

2.7.2 Attieke

Attieke preparation is generally the same as that of Gari. The slight difference is that it is steamed instead of toasting. The inputs used are the same (Kouakou et al., 2016). Compared to Gari, it has a shorter lifespan than Gari and only found in Cote d'Ivoire.

2.7.3 Tapioca

Tapioca is mainly consumed in Benin and Togo. Preparation begins by grating cassava roots then putting in water. Its then pressed and kneaded to ensure that starch is released (Ezedinma, 2017). This operation is repeated several times as starch settles at the container bottom and water drained off. The damp collected starch is then put in a pan, roasted as done in Gari to form a coarse granular product (Ezedinma, 2017).

2.7.4 Lafun

The production involves peeling cassava roots, soaking in water to ferment, bagging or dewatering, drying and finally milling into flour (Flibert et al., 2016). It is also produced by immersing peeled roots into a pool of water then fermenting the roots until it softens. The fermented roots are sundried and milled into cassava flour (Ezedinma, 2017).

2.7.5 Fufu

All production process done to Lafun is the same to Fufu. The only difference is that fermentation comes before pulverization and wet sieving (Flibert et al., 2016). The process continues by sedimentation or decantation, bagging or dewatering, granulation and finally flush drying (Nhassico, 2008)

2.8 MEASURING FOOD CONSUMPTION BY INDIVIDUALS

2.8.1 24 Hour food recall

In this method, the respondent is asked to remember in details and report the type and quantity of food and beverages consumed in the previous 24hours (Harris-fry et al., 2017). The respondent may also be asked about activities they undertook during the day to assist in recalling what they ate hence give information on estimating the level of activity and energy (Nurah, 2005). It's done through interviews and semi structured questionnaires are administered. The interviewers should be nutritionists or have knowledge in food and nutrition since the questions asked involves dietary information (Harris-fry et al., 2017). However, non-nutritionists may be used but they have to be trained in the use of the standardized equipment's. In both aspects, they should be knowledgeable about varieties of foods available in the market, there preparation practices and ethnic foods in the study area.

Specific probes through the structured forms would help respondents all foods consumed within that day (Thompson and Suber 2008).

2 .9 ESTIMATING NUTRIENT INTAKE FROM FOOD CONSUMPTION DATA

Nutrient intake estimations require conversions of the food taken into nutrient consumptions. Specific databases that use ideal computer programs to calculate nutrients are used to provide accuracy (Schlundt et al. 2009). The quantitative analysis of each sample of food should be obtained to estimate the nutritive value through the food composition database. The data collected should exhibit accuracy in terms of sampling, analysis and entry. However, a number of factors have to be considered like different sources, different farming practices, handling and even storage. These therefore require use of several methods of analysis especially for local foods, its ideal to use direct laboratory chemical analysis (Gibson, 2005).

2.10 DIRECT CHEMICAL ANALYSIS

The food items will be randomly uprooted from various farms. Only the two mostly consumed cassava roots varieties will be selected. Measures must be undertaken to obtain a representative sample. Sample protocol considerations entails factors like the genetic variations, maturity stages, handling and storage, differences in soil fertility, methods of food preparation, value addition and production practices (Gibson, 2005). The chemical analysis method will be exemplary accurate, precise and feasible. Measures will be taken in weighing, titration and calculation of specific contents. Despite of the cost effect of analysis, this will be carried out because the samples meet one of the listed criteria. Has inadequate (or data is non-existent) on the component of interest in the food, or the food as eaten; the food forms a significant component of the local diet and the food contributes significantly to the intake of the dietary component of interest (Gibson, 2005)

CHAPTER THREE: STUDY DESIGN AND METHODOLOGY

3.1 STUDY SETTING

The study was done in three Locations namely, West Kanyamkago, Orango Central and Kamgundho of Migori County (Figure 1).

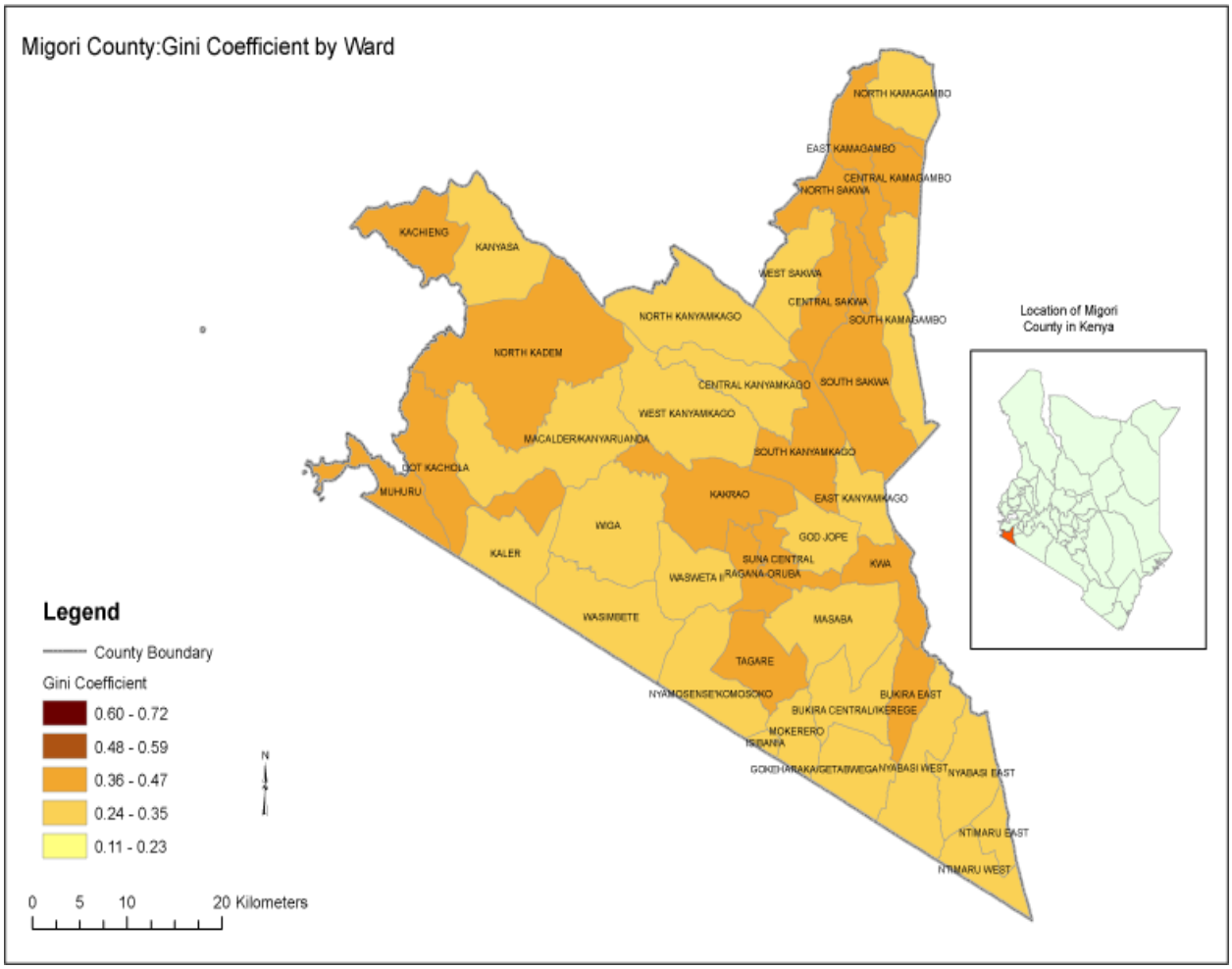

Figure 1. Migori County map by Wards. Source; Gini coefficient maps (2015)

3.1.1 Migori County

Migori County is one of the 47 counties in Kenya. It is situated in the south western part of Kenya neighboring Homabay, Narok, Kisii counties, Tanzania and Lake Victoria. It has a population of 917, 170 people with a density of 353 people per square kilometer of which 45% live below one dollar per day.

The inhabitants include Suba, Luos, Kuria, Abagusi, Somalis, Luhya, Indians Arabs and Nubians. The county has 4 sub counties namely, Migori, Nyatike, Rongo and Uriri with a total of 40 administrative wards. Major towns are Migori, Kihancha and Isebania.

The population's age distribution is classified as follows, those of 0-14 years are 49%, 15-64 years are 48%, and over 65 years being 3%. The main economic activities are Agriculture, fishing, manufacturing and mining. Small scale and micro enterprises in the Jua kali sector are undertaken.

The regions climatic conditions are not uniform, sugarcane growing zones are fertile and productive in terms of farm produce. Zones bordering Lake Victoria receive less rainfall hence drought and hunger. This study focus on specific areas within Migori County that majorly depend on Cassava as there source of energy. The identified areas were Orago central, Kamgundho and West Kanyamkago locations.

3.2 RESEARCH DESIGN

The study design was cross-sectional with both descriptive and analytical components in nature to meet the various goals. Survey was done to establish the socio-demographic characteristics of the population together with other qualitative data.

To obtain the percentage of dietary energy and protein obtained from cassava, observational analytical study was conducted. This was further used to determine the nutritional status of children 2-5 years old in the study area.

Determination of the protein and cyanide content of cassava flour and cooked ugali was done through Kjedhal distillation and silver nitrate titration methods respectively as described in AOAC (2010). All the cassava varieties grown in the area were identified and formed the total samples analyzed.

3.3 STUDY POPULATION

The study was conducted in households in Orango central, west Kanyamkago and Kamgundho lacations, in Migori County. The population studied comprised of the rural communities.

3.4 INCLUSION AND EXCLUSION CRETIRIA

3.4.1 Inclusion criteria

The study included households with children aged 2-5years.The other participants were mothers or immediate care givers who were also involved in cassava farming.

3.4.2 Exclusion criteria

The study excluded children below or above the age bracket, those who were not present in the households during the survey period and those children who visited during the study period.

3.5 SAMPLING

3.5.1 Sampling size determination

The sample size was determined using Fisher's formula (Fisher's et al., 1991) as follows:

$n= 2(z^2pq)/d^2$

Where:

n=the desired sample size

z=the standard normal deviation which is 1.96 at 95% confidence interval

p=proportion of wasted (low weight for height) children in Migori county being 8.6% (KDHS, 2015)

q=proportion of children in Migori County who are not wasted (q= (1-p) where p=0.086

d=the desired level of precision was set at 5%

2= No. of Sub Counties in Migori County surveyed

Therefore,

(n= $2(1.96^2 x 0.914 \times 0.086)/ 0.05^2$) =242 households

4% attrition= 242+ (104×242)/100 = 251.68

n = 253 households

3.6 SAMPLING PROCEDURE

3.6.1 Sampling scheme

Sampling was undertaken in Uriri and Nyatike Sub Counties within Migori County being purposively sampled since cassava production is intensive in these parts of the community (Figure 2). Nine villages formed the basis of the convenience sample. These areas were accessible and residents highly produce and utilize cassava as their main source of energy. A total number of two hundred and fifty three households were selected through random stratified sampling.

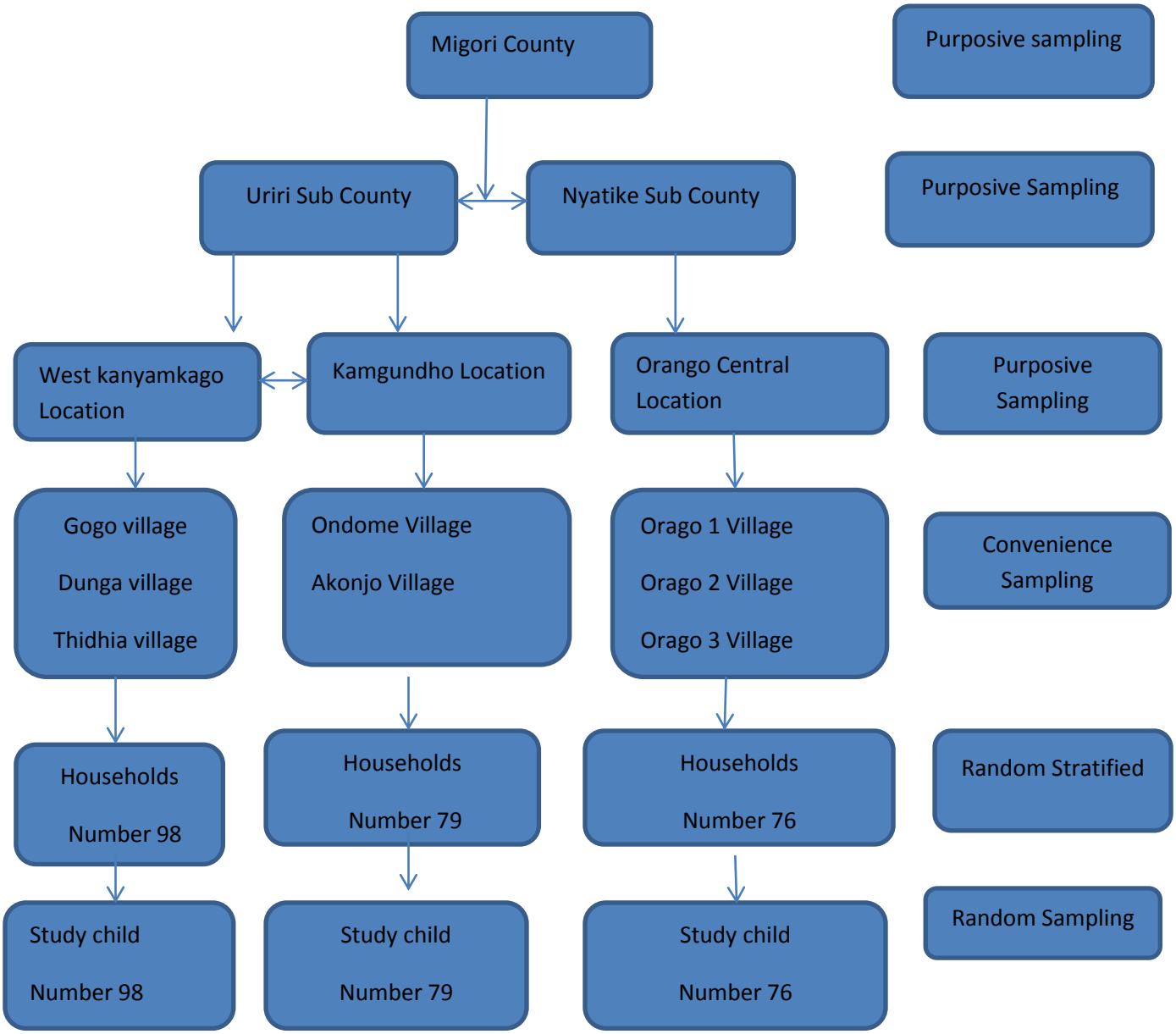

Figure 2. Sampling scheme

3.6.2 Sampling of cassava flour and cooked product

All the cassava flour produced from the existing varieties in the study area were bought from the farmers household's, packaged well and transported to the University of Nairobi food chemistry Laboratory for analysis. Measures were taken to prevent any moisture absorption. The varieties were seven of which both the variety flours and popular stiff porridge (ugali) were sampled and subjected to analysis. Cooking of ugali was carried out as done in the study area on all the different flour samples. Analysis was then carried out to determine the cyanide and protein content of the flours and ugali samples.

3.6.4 Determination of crude protein and cyanide content

Crude protein was determined by modification of the micro-Kjeldahl method described by Ashaye *et al.* (2015). A sample of 0.5g was weighed in a nitrogen free filter paper and put into the micro-Kjeldahl flask. 1 Kjeldahl catalyst tablet and 10 ml of concentrated sulphuric acid was then added to it. This was then subjected to digestion for four hours. About 100mls distilled water and a drop of phenolphthalein indicator was added to the digest. This was then subjected to distillation in distillation column by adding 40% (w/v) NaOH and the liberated ammonia collected into 250 ml conical flask containing 25ml of 0.1N HCL with methyl orange indicator added. The solution was then titrated against 0.1N NaOH solution. In calculating protein content, 6.25 were used as the conversion factor. The calculated results were based per 100grams dry basis.

3.6.5: Determination of cyanide content

Cyanide content was determined by weighing 100g of the sample in micro-Kjeldahl flask then adding 100mls of distilled water into the flask and let stand for at least two hours. This was then subjected to distillation using kjeldahl distillation unit and the liberated distillate

was collected into 250ml conical flask containing 25ml of 2.5% (w/v) NaOH solution and titrated with 5% potassium Iodide solution as per AOAC (2010) method number 4.093.

3.7 ANTHOPOMETRIC MEASUREMENTS

These are the children's physical body measurements. The respondents were requested to avail their children for measurements upon which weight, height and mid-upper arm circumference (MUAC) were measured and their age recorded**.** To maximize on accuracy, the measurements were taken in duplicates, after which the average was calculated and recorded.

3.7.1 Weight

The weight of the children was obtained using Salter weighing scale. The respondents were asked to remove excessive clothing from the children. The scale was zeroed before taking the measurement. The trained field assistant assisted in putting on the weighing pants in the children, and hanging on the scale. Readings was then recorded to the nearest one decimal place.

3.7.2 Height

To obtain the height, Excessive clothes such as sweaters, head scarfs and shoes were removed through respondent assistance, The child was then guided to stand up straight on the height board with their feet together, knees straight, and heels, buttocks and shoulder blade in contact with the vertical surface of height board. This was facilitated by the trained research assistants. Measurement of height was rounded off to the nearest 0.1 cm using a height/length board recommended by WHO.

3.7.3 Mid Upper Arm Circumference

MUAC of the children was measured using (MUAC) tapes recommended by (UNICEF, 2007). The respondents were asked to hold their child, and the tape wrapped round upper arm of the less active hand, mostly the left hand. The trained assistants then recorded the reading at the arrow mark.

3.8 DATA QUALITY ASSUARANCE

The quality of the data was controlled through proper training of the field assistants, close supervision of the field assistants during data collection by the principle investigator. Daily checking of questionnaire was done to ensure that they are correctly and completely filled, and data cleaning i.e. extreme entries and wrong entries were removed. Data measurements and recording was done in duplicates, measuring and laboratory equipment's were calibrated before use.

3.9 RECRUITMENT AND TRANING OF RESEARCH ASSISTANTS

Positions of five research assistants were advertised through posters in the study area, minimum grade being C+ and above in K.C.S.E. Different research assistants were recruited in different Sub Counties. They were then trained for two days. Topics covered included; interview techniques, how to obtain informed consent, taking of anthropometric measurements and assessment of nutritional status of children.

3.9.1 Pre-testing of research questionnaire

Pre-testing was undertaken in 20 randomly selected Households at Koguta Village in Homa Bay County away from the study site. The exercise involved the trained field assistants. The area exhibit the same characteristics as the study area, they grow and depend on cassava. The

activity was very essential because it enabled noting the appropriateness of the questionnaire, to understand time taken to complete a questionnaire, ability of meeting desired objectives and the competence of the enumerators who were involved in the survey.

3.10 RESEACH TOOLS AND EQUIPMENTS

Semi-structured questionnaire were used as the main research tool while the equipment used included salter weighing scale, height boards, MUAC tapes, kitchen scales and measuring cylinders. Laboratory equipment included Digester and kjeldahl distillation unit.

Household survey was undertaken and Data collected through face to face administration of the semi-structured questionnaires. A lot of information of the study population was obtained as per the various sections of the questionnaire that includes socio-demographic characteristics of the study population, cassava production practices, food frequency questionnaire, 24 hour recall, morbidity and nutritional status assessment.

Dietary assessment was done using the 24-hour recall method, food frequency questionnaire and dietary diversity scoring. Anthropometric assessment was done by measuring of weight and height. Clinical assessment involved looking out for physical signs of protein energy malnutrition.

3.11 DATA ANALYSIS

Statistical Package for Social Scientists (SPSS) version 20 was used to compute descriptive statistics, establish correlations between different variables, and compare means through analysis of variance and in carrying out t-tests. Energy and protein obtained from cassava based diets was calculated using Nutri-survey. Intakes will then be compared in terms of the Recommended Dietary Allowances (RDA) for age and sex to determine the percentage of requirement obtained from the diet. Nutritional status of the children was calculated using the

Emergency Nutritional Assessment software (ENA for SMART). Protein and cyanide results were analyzed using Genstat software.

3.12 ETHICAL CONSIDERATIONS

The proposal was presented to the graduate school, University of Nairobi for approval. The study area administrators were informed and consent obtained for the survey. The respective area village elders were used as guides during the survey. The respondents were informed on the purpose of the study, objectives, and possible benefits of the study by the survey team. Consent form was signed by each participant before the interview to be aware of terms and conditions of the process.

CHAPTER FOUR

4.0 RESULTS

4.1 Demographic characteristics of the study population

A total number of 253 households were sampled, recruited and administered with questionnaires in August 2018. The study population comprised of 1203 people of whom 48.2% were male and 51.8% women. The average household size was approximately 5. The mean age of the study children was 43.15 ± 12.52 months with a range of 24 - 59 months (Table 3).

Majority of the study population (20.8%) had completed primary school, 3.3% had attained secondary education, 5.0% tertiary, 7.1% had never gone to school, 26.5% were preschoolers while 31.9% and 9.7% did not complete primary or secondary schools respectively. The main occupation of the population was farming at 33.2% followed by business (5.7%) and Formal employment at 1.9%. Slightly over half of the peoples (57.6%) were either students or preschoolers. All the households in the study area were Christians. About 44.7% contributed towards the household income.

Table 3: Demographic characteristics of the study population

Variable	Total (%) N=1203
Gender	
Male	48.2
Female	51.8
Relationship to household head	
Household head	17.3
Spouse	17.2
Son or daughter	48.2
Relative	1.1
Employee	0.1
Contribution to house hold income	62.0
Education level	
Never gone to school	2.7
Not completed primary	31.9
Completed primary	20.8
Not completed Secondary	9.7
Completed Secondary	3.3
College/diploma	5.0
Preschoolers (<6 years)	26.5
Occupation	
Formal employment	1.9
Business	5.7
Farming	33.2
Casual laborer	1.1
Unemployed	0.7
Student	32.3
Preschoolers(<6years)	25.3
Marital status	
Married	37.2
Single	7.4
Separated	0.1
Divorced	0.1
Widowed	1.2
Not applicable (<14years)	53.9

4.2 Demographic characteristics of the study households heads

Majority of households were male headed (87.7%) and 97.1% were married. The association of male headed (P<0.003) and level of education (P<0.042) was statistically significant in comparison to the locations. Sixty five percent of the respondents attained primary level of education. Slightly over a quarter of the study population had secondary and tertiary level of education (28.8%) while less than ten percent (7.15%) were illiterate. Those who had formal employment were 4.0%, farmers 94.1% while 1.9% was casual laborers (Table 4).

Table 4: Demographic characteristics of the household heads by Locations

Household head characteristics	**Location (%) West Kanyamkago**	**Orango Central**	**Kamgudho**	**Total (%) N=253**	**(P-Value) (χ^2)**
Male headed household					
Male	79.0	94.3	93.1	**87.7**	**0.003**
Female	21.0	5.7	6.9	**12.3**	**(3.12)**
Marital status					
Married	97.0	95.7	98.6	**97.1**	**0.586**
Unmarried (single)	3.0	4.3	1.4	**2.8**	**(2.22)**
Level of Education					
Never gone to school	11.9	2.9	2.8	**7.1**	**0.042**
Primary education	66.3	65.7	63.9	**65.3**	**(14.12)**
Secondary and tertiary level	21.8	31.4	33.3	**28.8**	
Occupation					
Formal employment	2.0	2.9	7.0	**4.0**	**0.076**
Farmer	98.0	95.7	88.7	**94.1**	**(1.33)**
Casual laborer	0.0	1.4	4.2	**1.9**	
Contribution to house hold income					
Yes	98.0	100.0	98.6	**99.2**	**0.527**

4.3 Household economic activities

Majority of the total households (72.3%) lived on an average monthly income of below USD.50 while 24.9% of the households earned between USD 51 -USD 100. About 2.4% of the households earned between USD 101 - 250 while 0.4% earned above USD 251

The main source of income of the respondents significantly ($p<0.05$) differed across the three locations. The highest proportion in West Kanyamkago household had 91.7% income emanating from sale of crops or both crops and livestock. In Orango Central households, 93.3% sold crops and engaged in business. At Kamgundho 85% of the households income was generated from sale of crops or both crops and livestock (Table 5).

Table 5: Distribution of main source of livelihood and average monthly income of households in Migori County

Variable	Location (%) West Kanyamkago	Orango Central	Kamgudho	Total (%)	P-value (χ^2)
Main source of income					
Employment	4.1	4.0	10.3	**6.0**	**<0.001**
Sales of crop	81.4	92.0	62.8	**79.0**	**(32.2)**
Sales of livestock and their produce	2.1	0.0	12.8	**4.8**	
Business return	2.1	2.7	9.0	**4.4**	
Sales of crop and livestock	10.3	1.3	5.1	**6.0**	
Average monthly income in USD					
≤30	80.4	66.7	67.1	**72.3**	**0.220**
31 – 100	18.6	30.7	27.8	**24.9**	**(1.22)**
101 -250	1.0	2.7	3.8	**2.4**	
≥251	0.0	0.0	1.3	**0.4**	

4.4 Land ownership and agricultural farming practices

Table 6 shows the distribution of land ownership and size as per the locations. Most (97.2%) of the households owned land while only 2.8% did not own land in the County. The association of land ownership ($P<0.004$) and land size ($P<0.001$) was statistically significant

in comparison to the locations. The households in west Kanyamkago (77.1%) had land ranging from 1 to 10 hectares, 95.9% Orango central households land ranged from 0.1 to 5 hectares while 89.9% of Kamgundho household land ranged from 0.1 to 5hectares.

The proportion of agricultural activity done among the households included crop production at 41.1%, livestock rearing were 2.0% while those who practiced both crop production and livestock were 56.9%.

Table 6: Distribution of land ownership and size as per the locations

Variable	Location (%)			Total (%)	P-value (χ^2)
	West Kanyamkago	Orango Central	Kamgudho		
Ownership of land					
Yes	100.0	98.6	92.3	**97.2**	**<0.004**
No	0.0	1.4	7.7	**2.8**	**(15.12)**
Approximate size of the land owned (hectares)					
Below 1	5.4	5.4	28.0	**12.4**	**<0.001**
1 to 5	71.7	90.5	70.7	**77.3**	**(24.2)**
6 to 10	20.7	4.1	1.3	**9.5**	
Above 10	2.2	0.0	0.0	**0.8**	

The proportion of agricultural activity done among the households included crop production 41.1%, livestock rearing were 2.0% while those who practiced both crop production and livestock were 56.9%.

The crops grown within the households varied. Among the starchy food crops, cassava was the most preferred followed by maize. The other crops included beans, ground nut, millet and vegetables. The cash crops were tobacco and sugarcane.

Rateng' (34.5%) was the most preferred cassava variety grown by the households. Approximately 57.4% of the residents grew a mixture of various species (Table 7)

Table 7: Distribution of Farming activities in Migori County

Variable	Proportion (%)
Agricultural activity	
Crop production	41.1
Livestock rearing	2.0
Both	56.9
Crops grown	
Maize and beans	5.5
Maize, beans and cassava	22.1
Millet, beans and maize	17.8
Maize, beans, cassava and nuts	9.9
Cassava, millet, potatoes and maize	21.7
Millet, cassava, nuts, beans, maize and vegetables	10.3
Maize, beans, cassava, tobacco and sugarcane	12.6
Species of cassava cultivated	
Rateng'	34.5
Obarodak	6.0
Rapado	2.1
Mixture of species	57.4

4.5 Cassava sources and consumption Patterns

Ninety four (94%) of the households consumed cassava of which 88.4% produced cassava for their own consumption. About 11.8% purchased the cassava they consumed while 6% of the households did not consume cassava. Source of cassava was significantly ($\mathbf{X^2}$ = 0.010, P<0.05) associated with the location of the households. Kamgundho (94.8%) had the highest proportion of households consuming cassava from own production followed by Orango Central (89.1%) and West Kanyamkago (82.3%) (Table 8).

Table 8: Dietary pattern and source of cassava consumption per locations

Variable	Location (%)			Total	P-Value (χ^2)
	West Kanyamkago	Orango Central	Kamgudho	(%)	
Consumption of cassava					
Yes	96.9	86.7	97.5	**94.0**	**0.010**
Source of cassava consumed					
Own production	82.3	89.1	94.8	**88.2**	**0.032**
Market	17.7	10.9	5.2	**11.8**	**(6.48)**

4.5.1 Form and source of cassava consumed

The association between the form of cassava consumed ($p<0.005$), variety of cassava consumed ($p<0.005$) were each statistically significant to location. The highest proportion of households from West Kanyamkago (85.9%) and Orango central (74.6%) obtained their cassava in form of processed cassava products; while 50% from Kamgundo in the form of unprocessed cassava roots (Table 9).

The most preferred cassava variety in west Kanyamkago were Rateng', Obarodak and Exotic at 83.4%, Orango central cultivated Rateng' and Rapado at 96.5% while Kamgundho households preferred Obarodak and Rapado at 94.2% (Table 10).

Table 9: Form of cassava consumed in the study area

Variable	Location (%)			Total	P-Value (χ^2)
	West Kanyamkago	Orango Central	Kamgudho		
Processed and unprocessed roots	14.1	25.4	50.0	**29.0**	**<0.001 (32.44)**
Processed cassava product	85.9	74.6	47.4	**70.1**	
Unprocessed cassava roots	0.0	0.0	2.6	**0.9**	

Table 10: Distribution of variety of cassava consumed by location

Variable	Location (%)			Total (%)	P-Value (χ^2)
	West Kanyamkago	Orango Central	Kamgudho		
Rateng	65.6	93.0	1.4	**52.3**	**<0.001 (221.16)**
Obarodak	12.2	1.8	36.2	**17.1**	
Exotic and Obarodak	17.8	0.0	0.0	**7.4**	
Majero	3.3	1.8	0.0	**1.9**	
Rapado	0.0	3.5	58.0	**19.4**	
Nyadundo	1.1	0.0	4.3	**1.9**	

4.5.2 Stoppage in the continuous consumption of cassava products

In total about three out of ten households stopped consuming cassava in a given time (Table 11). Among this group their reasons for disturbance of cassava consumption was statistically significant (P=0.007) across the three locations (Figure 3). The major reasons across the three locations were low yield due to disease attack and lack of capital for cassava farming.

Table 11: Disturbance in the continuous consumption of cassava

Once stopped Consuming cassava	Location (%)			Total (%)	P- Value (χ^2)
	West Kanyamkago	Orango Central	Kamgudho		
Yes	27.8	30.4	38.0	**31.8**	**0.341**
No	72.2	69.6	62.0	**68.2**	**(2.15)**

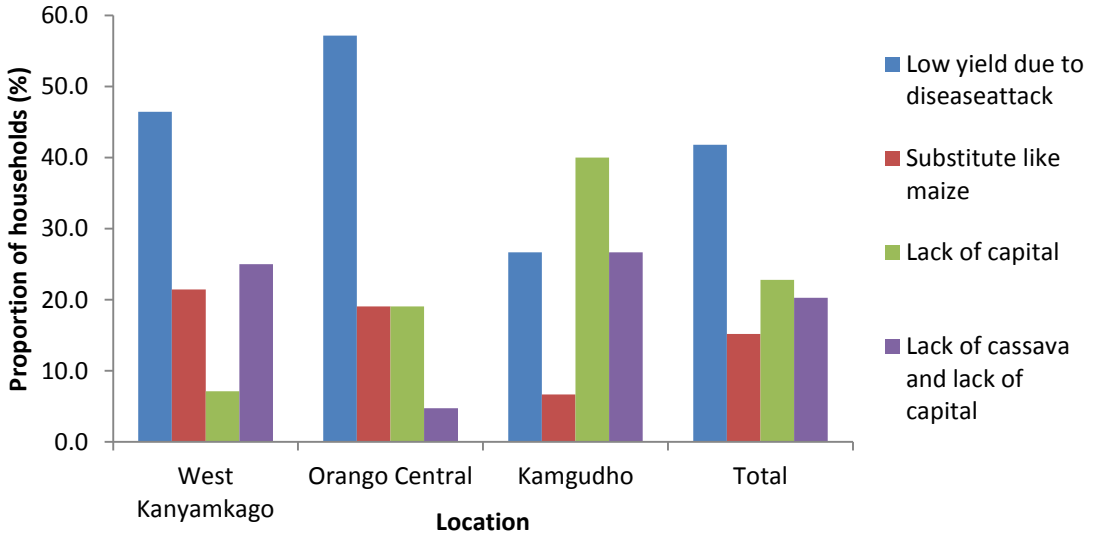

Figure 3. Reason for stoppage of consumption of cassava among households in Migori County

4.5.3 Consumption of cassava leaves in the study area

The association between cassava leaves consumption and locations was statistically significant (P<0.05). In west Kanyamkago, 94.8% had never consumed cassava leaves, 98.6% in Orango Central while 95.2 % in Kamgudho (Table 13). The low consumption of cassava leaves was attributed to various perceptions. 33.6% of the household's believed that leaves were harmful, 42 .5% did not know how to prepare the leaves while 23.9% preferred other vegetables. Knowledge that cassava leaves are edible is described in Figure 4 and 5.

Table 12: Consumption of cassava leaves in the study area

Variables	Location (%)			Total	P-Value (χ^2)
	West Kanyamkago	Orango Central	Kamgudho	(%)	
Cassava leaves consumption	5.2	1.4	9.0	**4.8**	**0.017**
Yes					**(12.03)**
No	94.8	98.6	91.0	**95.2**	
Preparation method					
Fry in oil	3.1	0	2.7	**6.4**	**0.405**
Clean and boil	3.1	0	6.8	**10.3**	**(1.81)**
Dry and grind into flour	0.0	0	1.4	**1.3**	
Cassava leaves cooking methods					
boiled cassava	16.7	0	12.5	**14.3**	**0.019**
fried cassava	33.3	0	0.0	**14.3**	**(11.9)**
Mix with other veg	0.0	0	12.5	**7.1**	
Boiled and fried cassava	50.0	0	12.5	**28.6**	
Kasumba	0.0	0	62.5	**35.7**	
Perception of consuming cassava leaves					
Harmful	40.0	34.1	27.0	**33.6**	**0.827**
Not know how to prepare	37.1	43.9	45.9	**42.5**	**(1.49)**
Prefer other vegetables	22.9	22.0	27.0	**23.9**	

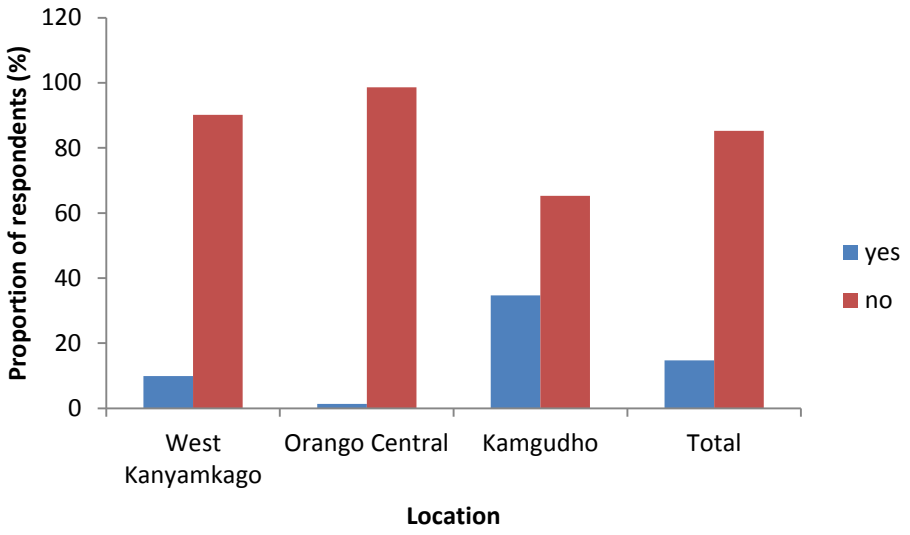

Figure 3. Proportion of respondents with knowledge that cassava leaves are edible across the locations

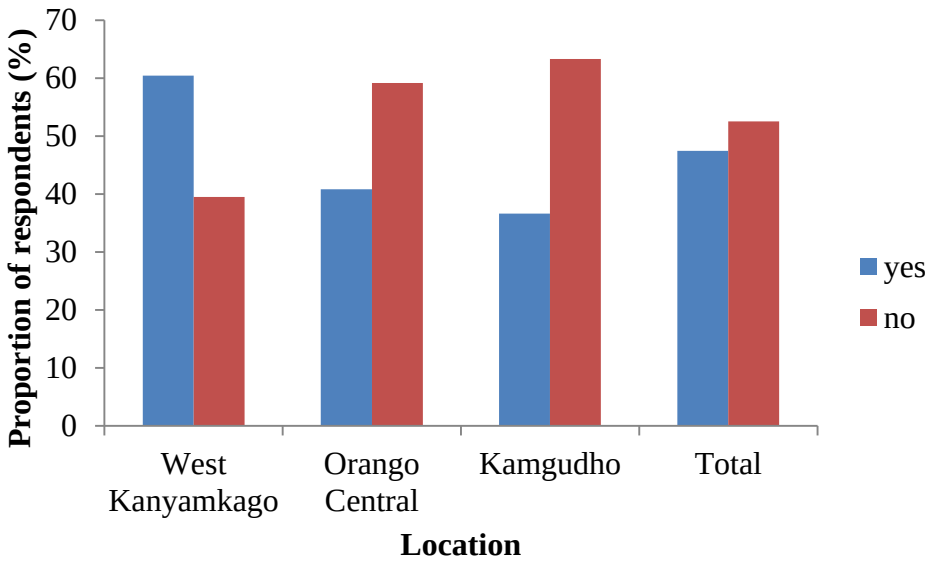

Figure 4. Willingness to consume cassava leaves among those who don't consume.

4.6: Dietary diversity of children 2-5 years in the study region

The mean dietary diversity score (DDS) for children was 4.31±0.94 with a range of 1 -7 food groups. The overconsumption of cassava was insignificant predictor of the dietary diversity score ($p>0.05$). The mean DDS scores significantly ($p<0.05$) differed by residence of the children (Table 13).

Table 13: Distribution of mean dietary diversity score by Study County

Residence	Mean DDS score
Sub-County	
Uriri	4.21±0.94[a]
Nyatike	4.49±0.93[b]
Location	
West kanyamkago	4.04±0.97[a]
Orango central	4.49±0.92[c]
Kamgudho	4.44±0.84[b]
Sub-Location	
Kajulu 2	4.04±0.97[a]
Got orange	4.49±0.92[c]
Kamgudho1	4.44±0.84[b]
Villages	
Gogo	3.71±0.72[a]
Thithia	3.92±0.67[ab]
Orango 1	4.54±0.94[b]
Dunga	4.37±1.14[b]
Ondome	4.33±0.89[ab]
Akonjo	4.51±0.74[b]
Orango 3	4.32±0.89[ab]
Orango 2	4.60±1.14[ab]

Mean DDS above 4.00 is recommended by UNICEF/WHO standards.

Values with different superscripts for a variable are statistically different at $p<0.05$.There was a significant ($p<0.05$) positive correlation (0.17) between household size and the DDS score of the children. The age of the child had no significant ($p>0.05$) correlation with the DDS score of the children. The gender of the child had no significant ($p>0.05$) influence on the DDS score of the children.

4.7: Amount of dietary energy and protein obtained from cassava by children aged 2-5 years

Children from Kamgundho location consumed the least total energy (1168.49 kcal, RDA 57.17%) as compared to West Kanyamkago and Orango Central as shown in Table 15.The main consumed cassava based products were ugali and porridge. Cassava energy obtained from these products was highest in Orango Central (491.94kcal, 23.98% RDA) followed by Kamgudho (481.80kcal, 23.65% RDA) and West Kanyamkago (277.10kcal, 13.62% RDA). The average amount of protein energy obtained from cassava from the three locations was less than 1 kcal (Table 15).

Table 14: Mean energy (kcal) consumed by children per locations in Migori County

Food	Location	Energy(kcal)	% RDA energy	Protein (kcal)	% RDA protein
All foods	West Kanyamkago	1709.98 ± 861.94^{Aa}	83.99 ± 42.32^{Aa}	38.87 ± 21.97^{Aa}	64.57 ± 36.62^{Aa}
	Orango Central	1435.22 ± 263.13^{Aab}	70.48 ± 12.92^{Aab}	45.32 ± 25.93^{Aa}	75.40 ± 43.13^{Aa}
	Kamgudho	1168.49 ± 425.35^{Ab}	57.17 ± 20.98^{Ab}	33.83 ± 18.05^{Aa}	55.73 ± 29.49^{Aa}
Cassava	West Kanyamkago	277.10 ± 213.05^{Ba}	13.62 ± 10.38^{Ba}	0.46 ± 0.05^{Ba}	0.76 ± 0.08^{Ba}
	Orango Central	491.94 ± 324.53^{Bc}	23.98 ± 15.75^{Bc}	0.82 ± 0.08^{Bc}	1.34 ± 0.14^{Bc}
	Kamgudho	481.80 ± 439.52^{Bb}	23.65 ± 23.59^{Bb}	0.79 ± 0.72^{Bb}	1.32 ± 1.15^{Bb}

Values with different superscripts preceded with a similar capital letter along a column are significantly different at $p<0.05$

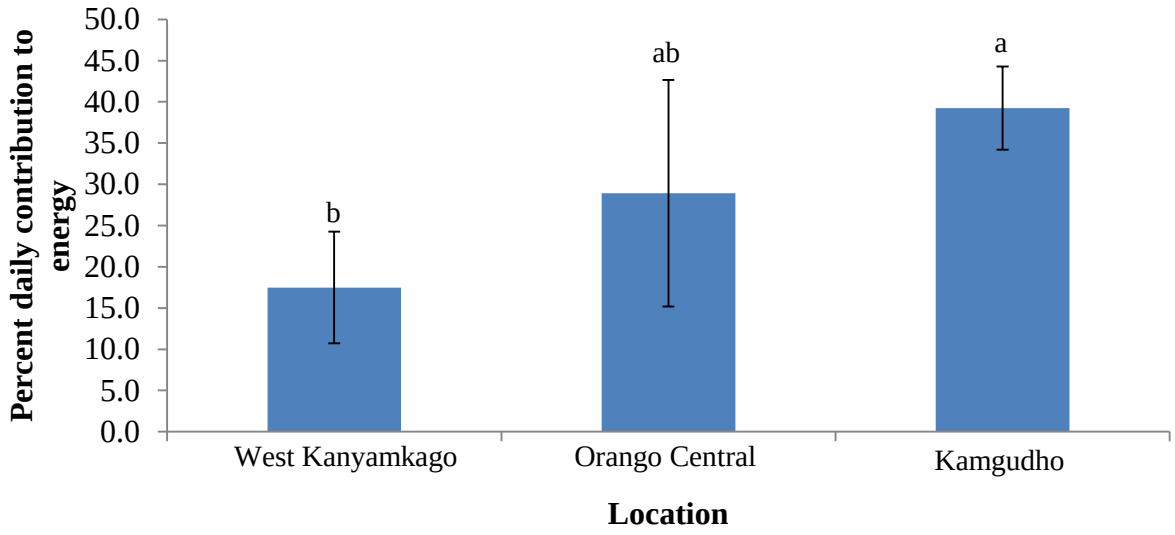

Figure 5. Daily contribution of cassava to daily intake of energy in Migori County.

4.8 Protein and cyanide content of cassava flour and product of consumed cassava varieties in Migori County

There was a negative correlation (-0.4) between cyanide and moisture contents of cassava flours. The average protein content of dry cassava flours (on as is basis) was 2.47% with Adhiambo Lera (1.67%) having the least and Obarodak (3.42%) was having the highest. Cyanide contents showed that the varieties that had the highest contents were Exotic (72.3mg/Kg) and Raten'g (74.9mg/Kg) as bitter cassava shown in Table 15.

The most preferred cassava cooked and consumed product in the study area was ugali. Analysis undertaken showed decrease in both the protein and cyanide levels of cooked ugali compared to the raw dry flours. There was a positive correlation (0.32) between cyanide and moisture contents whereas a negative correlation (-0.31) between cyanide and protein contents. The protein content from all the cooked ugali varieties were less than 0.5%, whereas the cyanide levels reduced to < 20mg/Kg as shown in Table 15. Only two products had cyanide of 10mg/kg or below as recommended by WHO.

Table 15: Moisture, Protein and Cyanide contents of cassava flours and cooked Ugali from Migori County Kenya

Cassava variety	Flour			Ugali		
	Moisture content (g $100g^{-1}$)	Protein content (g $100g^{-1}$)	Cyanide content (mg kg^{-1})	Moisture content (g $100g^{-1}$)	Protein content (g $100g^{-1}$)	Cyanide content (mgkg^{-1})
Adhiambo						
Lera	$11.53+0.30^{c}$	$1.67+0.03^{a}$	$47.0+2.20^{c}$	$35.09+0.01^{a}$	$0.22+0.01^{d}$	$17.10+0.50^{a}$
Exotic	$12.61+0.33^{b}$	$2.08+0.24^{a}$	$72.3+1.60^{a}$	$32.97+0.02^{c}$	$0.37+0.01^{b}$	$9.90+0.50^{c}$
Market	$11.49+0.31^{c}$	$2.01+0.82^{a}$	$55.0+1.60^{b}$	$35.83+0.03^{a}$	$0.47+0.02^{a}$	$16.20+0.60^{a}$
Nyakomiero	$12.29+0.06^{bc}$	$3.19+1.22^{a}$	$47.5+0.10^{c}$	$34.69+0.42^{ab}$	$0.36+0.01^{b}$	$10.70+0.80^{c}$
Obarodak	$12.38+0.04^{bc}$	$3.42+0.02^{a}$	$46.9+0.80^{c}$	$33.69+0.42^{bc}$	$0.30+0.01^{c}$	$11.00+0.50^{c}$
Rapado	$14.36+0.33^{a}$	$2.53+0.02^{a}$	$29.0+1.60^{d}$	$33.05+0.05^{c}$	$0.09+0.01^{f}$	$15.60+0.70^{ab}$
Raten'g	$12.54+0.03^{b}$	$2.23+0.42^{a}$	$74.9+0.70^{a}$	$31.48+0.66^{d}$	$0.17+0.01^{e}$	$13.60+0.30^{b}$

Values with different letters in the superscripts along a column are statistically different at $p<0.05$.

4.9 Morbidity experience of the children

Majority of the children 59.3% were found to have been sick 14 days prior to the study. The most prevalence illness in the study area was Malaria (44.6%), Diarrhea (2.8%), coughs and upper respiratory infections (2.0%), Typhoid (1.2%) among combination of diseases. Most of the caregivers (84.4%) took their children to the hospital when sick. Physical signs of malnutrition were observed in 22.6% proportion of the children. Dry peeling skin (15.2%) and Hair discoloration (47.8%) were the highest symptoms of malnutrition as shown in Table 16.

Table 16 Morbidity experience of children in Migori County per location

Medical history	Location (%)			Total Average	P-Value (χ^2)
	West Kanyamkago	Orango Central	Kamgudho		
Sickness in the last 14 days					
Yes	54.7	54.1	70.1	**59.3**	**0.067**
No	45.3	45.9	29.9	**40.7**	**(5.41)**
Action taken in case of child sickness					
Take to hospital	90.4	73.0	86.2	**84.4**	**0.074**
Given medicine	9.6	27.0	13.8	**15.6**	**(5.21)**
Presence of physical signs of malnutrition					
Yes	28.4	28.4	9.5	**22.6**	**0.030**
No	71.6	71.6	90.5	**77.4**	**(10.54)**
Symptoms of Malnutrition					
Edema	0.0	5.3	0.0	**2.2**	**0.116**
dry/peeling skin	11.5	21.1	0.0	**15.2**	**(15.45)**
hair discoloration	46.2	52.6	0.0	**47.8**	
abdominal distention	11.5	21.1	0.0	**17.4**	
excessive loss of muscle and tissue	11.5	0.0	0.0	**6.5**	
Loss of appetite	19.2	0.0	0.0	**10.9**	

4.9.1 Nutritional status of the children

Table 17 gives a summary of the nutritional status of the children in the study area. The mean weight for height, weight for age and height for age for the children was 0.44±2.15 (%), 0.13±1.99 (%) and 0.226±1.33 (%) respectively. The mean MUAC measurement was 16.08±1.23 cm with a minimum and maximum of 10 and 19.5cm, respectively. It shows that, for prevalence of underweight, approximately 1.2% was severely underweight, 4.0% were moderately underweight, and 9.5% were overweight while 85.4% of the children had normal weight for age.

Cases of stunting showed that the prevalence of moderately and severely stunted were more less equal standing at 7.5% and 7.1% respectively. A proportion of 85.4% had normal height for age.

Severe wasting was observed in 6.3% of the children. Only 7.1% were moderately wasted while 86.6% were normal.

MUAC readings showed that majority (99.2%) were normal and only 0.8% had severe malnutrition.

Table 17: Nutritional status of children 2-5 years in Migori County

Nutritional indicator	Nutritional status	Proportion (%) n=253
Weight for age Z-score	Normal (>-2SD to 2SD	85.4
(Underweight)	Underweight(<-2SD to<-3SD)	5.2
	Overweight(>2SD)	9.5
Height for age Z-score	Normal (>-2SD)	85.4
(Stunting)	Stunted(<-2 to <-3SD)	14.6
Weight for height Z-score	Normal >-2 SD	90.8
(Wasting)	Wasted (<-2 to <-3SD)	9.2
MUAC	Normal (MUAC >12.5 cm)	99.2
	Severe malnutrition (MUAC<11.5cm)	0.8

Table 18: Pearson correlation between DDS and nutritional status of children in Migori County

Nutrition status indicator	Pearson Correlation P-Value
Weight for height	0.08 0.181
Height for age	-0.07 0.909
Weight for age	0.07 0.265
MUAC	0.23 0.713

Regression analysis revealed no significant ($p>0.05$) predictor model of socio-demographic and economic characteristics on the weight for height, height for age and weight for age of the children.

The gender of the child was not significantly ($p>0.05$) associated with the weight for age, height for age, weight for height and MUAC of the children.

Table 19: Mean square values of the general linear model of socio-demographic factors on nutritional status

Dependent Variable Source	DDS F - Value	MUAC F- Value	Weight for height P-Value
Corrected Model	0.750	0.946	0.771
Intercept	103.473*	721.433	0.201
Sex of household head	0.776	0.400	0.913
Marital status of household head	0.647	0.627	0.746
Education level of household head	1.404	0.169	1.292
Occupation of household head	0.466	1.475	0.942
Age of household head	0.055	3.455	0.082
Adjusted R Square	-0.016	0.063	-0.015

*Significant at $p<0.05$

All the social demographic characteristics of the household heads in Table 19 were insignificantly associated ($p<0.05$) to DDS and nutritional status specifically weight for height.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Socio-demographic characteristics of the study population

Majority of the population were youths aged below 15 years depicting high burden to parents to provide basic amenities to sustain their livelihood. KDHS (2014) reported that the proportions of both women and men tend to decline with increasing age, reflecting comparatively the young age structure of Kenyan population. The ratio of female was slightly higher than male.

The mean household size in the study area was 5 which are the same with the national house hold size. As much as the national average includes both rural and urban settings, it remained the same KDHS (2014).

Majority of the population had only attained primary education certificate signifying low education level. This would promote unattractive employable society hence lowering their economic status. Farming and casual laboring would therefore be the only alternative for survival. As much as free secondary education was established to increase transition from primary to secondary by 70% percent in all districts (Ohba, 2009). The effect of free secondary education is not transferred effectively to the rural areas. Parents are required to meet other requirements like providing meals, transport to and from school and boarding fees for those in boarding which majority in the rural cannot afford (Mutegi et al.,, 2017). Inadequate education levels especially of care givers of children under five years would subject them to poor feeding practices hence promote malnutrition.

5.1.1 Social economic characteristics of the study population

Farming was the main source of livelihood in the study area. The main income obtained from crop farming and sale of livestock products. Majority of the households earned below 1.6 dollar per day. This predicts low income driven society who lack sufficient funds to facilitate some of their daily basic needs. The employment opportunities are very scarce and these are highly attributed to lack of factories in the locality of the study area.

Despite the low income obtained from sale of farm produce, majority owned their own land. This enabled them to obtain their food from their own produce hence meet their daily food requirement and keep reserve empowering them from food insecurity. The hindrance factors that affected food production includes, inadequate rainfall, use of traditional seedlings and poor agricultural practices as experienced in majority of the households. Cassava remained their main farm food reserve especially during draught period (Sharp, 2016).

5.2 Food consumption patterns in Migori County

5.2.1 Cassava utilization by the study population

Almost all the household studied consumed cassava with majority obtaining from their own farm. This is similar to the study done by Ngina (2012) in the coastal region where (98%) of the households consumed cassava. This means that cassava is highly valued as food crop in the study community. The community prefers cassava as their main food reserve taking note that it grows well in adverse harsh weather conditions especially in west Kanyamkago location. High consumption is similar to that of Mozambique where cassava is considered a principle food starch (Carlos, 2019). Consumption of cassava crop would promote its production to which therefore necessitates the need for high quality cassava production products (Kiura et al., 2002).

The main consumed cassava products by the majority of the population are fermented porridge and ugali. A study done in Nigera on the utilization of cassava for food revealed that, cassava is basically made into fermented and unfermented products. Fermented products include cassava bread, fermented cassava flour, fermented starch, fufu, lafun, akyeke (or attieke), agbelima, and gari (Falade et al., 2011). As much as traditional mechanisms were used in processing of tubers into flour, this seems to have promoted longevity in terms of shelf life when selling the produce. Draining of the wet chopped cassava helped in facilitating quick sun drying and reduction of hydrogen cyanide which are harmful to human health. The existence of cyanogenic glycoside which can be hydrolyzed to toxic hydrogen cyanide exhibits hindrance of the adoption of cassava as a major food item since (Masawi, 2017).

Majority of the consumers sold dry processed cassava chops in the market. This would later be milled for usage. This means that despite the perishability of cassava roots, no losses were incurred when sold on dry form. It thereby played a role in the communities' economic source of income.

Despite the fact that cassava leaves have a lot of protein, vitamin A and minerals, almost none of the households in the study area consumed the leaves. Majority were not aware that they are being consumed and if were aware, they still could not consume cassava leaves with perception that it's harmful. This could be due to availability of other vegetables like kales, cowpea and traditional ones. Unlike a study done in the coastal region where both roots and leaves were consumed by the majority (Nginya, 2014), this was not realized in the study area households. Likewise in Congo and Tanzania, cassava leaves are very important consumed vegetables and farmers usually prefer cassava breeds with large leafy canopies (Ezedinma, 2017).

There is underutilization of the cassava raw and processed products. There should be sensitization and introduction of the various nutritive cassava products in the area.

The most preferred cassava varieties are Raten'g and Obarodak. This is due to their resistance to diseases and high produce yield. Research institution should introduce new varieties that are first growing and disease resistant as observed in the coastal region. The varieties available are traditional with no consistent variety differentiation and naming.

5.2.2 Consumption of protein rich foods by 2-5 years children in Migori County

As realized by the 24hr survey recall data, almost ¾ of the children got adequate protein amount. The normal RDA for children 2-5 years ranges between 22-35 g/day (USDA, 2015). Majority of the children were able to receive sufficient amount of protein from their diets. Fish and fish products consumption especially Dagaa (Omena) consumption contributed highly. This is similar to study on the feeding practices of preschool children by their care givers in Limpopo province, South Africa at baseline and intervention level, where they consumed adequate amount of protein (Mushaphi et al., 2017). Despite high consumption of cassava, it only contributed to < 1% of protein requirement consumed by the children.

Adequate protein consumption shows why the three indicators of malnutrition were normal among the studied children comparable to the findings of KDHS (2014).

5.3 Protein and cyanide content of cassava flour and product of consumed cassava breeds in Migori County

The cassava breeds grown in the study area are about seven, the main ones being Obarodak and Rateng'. The breeds are basically the traditional varieties with the exception of Exotic breed from KALRO research institute. It was established that the cyanide levels on average on dry

flours was 53.23mg/kg while on consumed cooked ugali was 13.44mg/kg. These levels are above the required minimum of 10mg/kg of dry flour (Onabolu et al., 2008). This means that there are risks of negative effects of consuming high levels of HCN especially in long term utilization (Nhassico et al.,2007). Quick measures need to be taken to introduce low cyanide level cassava breeds. This also explains why the most consumed cassava products were ugali and fermented porridge since other products like boiled cassava roots, Crisps would be so bitter to consume. There was reduction of CN levels of the flour to their respective ugali products of all the grown breeds to an average of about 60%. This agrees with the literature studies that reveal that cooking of cassava flours reduces the amount of cyanide levels (Bradbury & Denton, 2014). To explain this concept, as cassava flour is mixed with boiling water to cook the ugali, enzyme linamarase acts on cyanogenic glycosides to form HCN enzymes which are inactivated hence reduction (Bradbury & Denton, 2010).

It was established that the protein content of both cassava flour and cooked ugali were extremely low. Cassava leaves have high amount of protein and vitamins but not consumed in the study area. This poses the risk of malnutrition especially to children of 2-5years if other avenues of protein are not realized. The protein levels are the same with the results done in the coastal region of Kenya by Ngina (2014).

5.4 Nutritional status of children 2-5 years

Nutritional status of the children was based on the new WHO 2006 standard. The resulting factors that contribute to malnutrition are many and categorized into immediate, underlying and basic causes (UNICEF, 1998).

The finding of the study indicates that the prevalence of stunting at the time of study was 14.6% of which 7.1% children were severely stunted. This indicates that an adverse effect of prolonged and in adequate food provision was realized. Prevalence of overall wasting is below the Kenyan average (26%) but those who are severely stunted are almost similar (KDHS 2014, Macro 2010). This what poses danger to the children because they are at high risks of being short and impaired structurally, brain damaged and premature development of cognitive functions and cognitive impairments (Kar et al. 2008, Kathryn and Khadija, 2011).

Children who were underweight during the time of study were 5.2 % with 1.2% being severely underweight. These findings are almost half percentage obtained by a similar study done in the same area where 9.6% of the children were underweight and 4.8% were severely underweight (Agatha , 2017). The reason is that after many years of shortage of rain and poor harvest in the area, the time proceeding to the survey, the harvest was good and there were plenty of other foods besides cassava within the households.

The prevalence of wasting at the time of study was 9.4. This is slightly higher than the national average of 4% (USAID 2018, KDHS 2008). However there was a weak positive correlation between the dietary diversity score and the degree of weight for height. This could be caused by high prevalence of malaria and diarrhea among majority of the children in the households prior to the study.

5.5 Morbidity experience of children 2-5years

The major causes of child morbidity and mortality in Kenya are acute respiratory infections, malaria and dehydration resulting from severe diarrhea (KDHS, 2014). The other determinants are inadequate and in balanced food provision which would prompt to malnutrition.

Majority of the children were sick two weeks prior to the survey. The common illnesses in order of dominance were malaria, diarrhea, upper respiratory infections and typhoid among others. The high prevalence of malaria among the children is associated with the favorable weather conditions in the area for the breeding of female anopheles mosquitoes that cause malaria. Lack of clean treated water, poor cooking hygiene standards, Use of chocking firewood for cooking would be the reason of diarrhea, typhoid and respiratory problems respectively.

The main signs of malnutrition were dry peeling of skin and hair discoloration. This would mean that caregivers in some households who did not provide their children with diverse protein rich foods and depended only on cassava were the most affected.

CHAPTER SIX

6.0 CONCLUTIONS AND RECCOMMENDATIONS

6.1 Conclusion

Majority of the residence practiced small scale mixed farming as their main source of livelihood. Most of the residents are primary graduates. The society has many youths (32.3%) below fifteen years.

Cassava is grown and consumed in almost all the households mainly in the form of fermented porridge and ugali. It is the major starchy food grown in the area. Growing of the traditional bitter cassava breeds puts the residence especially children at risks of hydro-cyanide related health problems. Majority of the residence do not consume cassava leaves and are not even aware that they are being consumed. This denies the Migori County residents vital available nutrients in their diet.

Cassava consumption provides to the children almost a third of energy and less than one percent of protein of their daily nutrient requirement. The assessment on dietary diversification in the study area is good; majority of children consumes more than four food group in their daily food intake.

It is evident from the three measured indicators of malnutrition that the children were generally normal. However, malnutrition still exists and the major challenge is high prevalence of morbidity among the children.

6.2 Recommendations

There is need of introducing new and known sweet cassava varieties that mature faster and have low cyanide content by research institutions through the initiative of County government. This would reduce health problems associated with hydro cyanide.

The residents should be informed and educated on the various cassava based products so that they optimize cassava utilization. For example they are not aware that cassava leaves are consumed yet are protein and vitamin A rich vegetables. Exchange programs to the farmers through the county government would be more appropriate. Consideration of other products like cassava crisps, chips and boiled fried cassava is more advisable.

Due to high production of cassava in the study area, marketing of the produce is a challenge to farmers. Suitable investors need to be encouraged to set up cassava flour processing factory in the area. Through fortification using other products to enrich the cassava flour, high returns would be achieved. This would thereby improve the economic status of the households in the study area.

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APPENDICES

Appendix 1: Informed Consent Form

Hallo. My name is _____. I am a student, conducting research with the University of Nairobi, which is assessing the contribution of cassava to nutrition and the nutritional status of children 2-5 years. This research is being conducted in Migori County and your household has been sampled randomly as one of the households that qualify to participate in his research. The research would be of benefit to you through your leaders and county Government since a copy of the findings will be given to those offices.

We promise you that any information you share with us will remain a secret between you and the researchers, nobody else will get to know about it. It will only be used to prepare the final report which will not contain any name of the respondents who participated. There will be no way of identifying those who participated in the survey. We kindly request you to participate.

If it's okay with you, we will proceed to ask you the questions in our questionnaire.

Respondent agree to be interviewed 1=Yes 2=No

Signature of the Interviewer_____

Date_____

Appendix 2: Research Questionnaire

General Information on the Study population

1. Questionnaire No._____ 2.Household No._____
3. Date of the study_____
4. Constituency/district_____
5. Location_____
6. Sub-location_____
7. Village_____

Section 1: DEMOGRAPHIC PROFILE

Person No.	Name	Age	Sex	Marital Status	Rshp to HH Head	Education. Level	Occupation	Contribution. to HH Income	Current Weight
1									
2									
3									
4									
5									
6									
7									
8									

Codes

SEX
1=male
2=female

Marital Status
1=married
2=never been married
3=separated
4=divorced
5=widowed
6=Not applicable(<14 years)

Relationship to the Household Head
1=Household head
2=spouse
3=son/daughter
4=relative
5=employee
6= others (specify)_____

Education level
1=never gone to school
2=not completed primary
3=completed primary
4=not completed secondary
5=college/diploma
99=Not applicable (<6 years)

Occupation
1=formal employment
2=Business
3=Farming
4=Casual laborer
5=unemployed
6=student
99= others (specify)

Contributes to household income
1=yes
2=no

Section 2: Household economic activities

1. What is your main livelihood activity?
   1=employment
   2=crop farming
   3=livestock rearing
   4=self-employed/business
   5=others (specify)_____
2. What is your main source of income?
   1=employment
   2=sale of crops
   3= sale of livestock and their produces
   4=business returns
   5= casual labor
   6=others (specify) _____
3. What is your average monthly income (ksh), all sources combined?
   1= 5,000 and below
   2=between 5,001 and 10,000
   3=between 10,001 and 25,000
   4=above 25,001

4. Does your household own any land?
   1=yes
   2=no

(*If no, proceed to 3)*

5. if yes, what is the approximate size of this land?_____(*record the units too*)
6. Does your household practice any form of agriculture?
   1=yes
   2=no
7. If yes, which agricultural practice do you engage in?
   1=crop production

   2=livestock rearing

   3=both

8. *(if the household grows crops*), which are the major crops that you produce(*list*)
   1=
   2=
   3=
   4=
   5=
   6=
   (*If cassava is not on the list, probe if they produce and include on the list if they do)*
   (If no cassava is produced at all, proceed to question 7)
9. If cassava is produced, which variety(s)/genotype do you normally produce?

1=_____
2=_____
3=_____

Section 3: Household cassava consumption practices

10. Does your household consume cassava?
    1=yes
    2=no (*if no, proceed to question 14)*
11. If yes, where do you normally obtain the cassava you consume from?
    1=own production
    2=local open air market
    3=super market
    4=Other sources (specify)_____
12. In which form do you normally obtain and consume the cassava?
    1=unprocessed cassava (either roots or leaves)
    2=Processed cassava products (specify product and name) _____
    4=Other forms (specify)_____
13. Which cassava variety/genotype(s) do you normally consume?
    _____
14. Has your household ever stopped consumed cassava?
    1=yes
    2=no
15. If yes, why did you stop consuming cassava? (*can give more than one response)*
    1=_____
    2=_____
    3=_____
16. Have you ever consumed cassava leaves?

    1=yes

    2=no

17. If yes, how do you normally prepare the leaves for consumption

    Meal name: _____

    Preparation method: _____

    If no, are you aware that they are edible (they can be eaten)?

    1=yes

2= no *(if no proceed to 20)*

18. If yes, why don't you eat them?

    1=_____

    2=_____

    3=_____-

19. If no, would you eat the leaves now that you know they are edible?

    1=yes

    2=no

20. If no, kindly let me know why you still cannot eat them

    1=_____
    2=_____

    3=_____

21. If cassava is consumed, kindly describe the most commonly followed method of preparation, and the name of the final product /meal

Meal name:_____

Preparation
method_____
_____

Section 4: Food frequency questionnaire

For each food item below, kindly let me know the category that best describes the frequency with which your child usually eats that particular food item (*enumerator to indicate with a check mark*)							
Food item	more than once daily	Once per day	3-6 times per week	Once or twice per week	Once per month or less	Never	Estimated amounts at every consumption time (mls)
Maize meal							
Irish potatoes							
Dark green leafy vegetables							
Sweet potatoes							
Pumpkin							
Spinach							
Ripe papaya							
Eggs							
Fish (liver intact)							
Chicken or other fowl							
Beef (sheep/goat meat)							
Milk and its products							
Beans							
Cassava crisps, Fries boiled Leaves							
Rice							
Cooked bananas							
Sorghum							

5: 24 HOUR DIETARY DIVERSITY SCORE

Kindly let me know the foods your child consumed in the past 24 hours

QUESTION NUMBER	FOOD GROUP	EXAMPLE
1.	Grains, root and Tubers	Maize, wheat, rice, millet, sorghum and any other grains or foods made from these (e.g bread, noodles, porridge, ugali,nyoyo Irish potatoes, Sweet potatoes, cassava, Yam (Nduma) or other foods made from these (e.g. chips/French fries,
2.	Legumes and Nuts	Dried beans, dried peas, lentils, Ground nuts, green grams, or food made from these e.g. peanut butter
3.	Vitamin A rich vegetables and tubers	Pumpkin, carrots, squash, orange-fleshed sweet potato, other locally available vitamin A vegetables e.g. red sweet pepper, Dark green-leafy vegetables including wild forms and locally available vitamin A rich leaves such as amaranth, cassava leaves, kales, spinach e.t.c
4.	Dairy products – Milk and Milk products	Milk, cheese, mala, yogurt,
5.	Other Fruits and Vegetables	Other vegetables e.g. tomato, onion, green bananas and any other locally available vegetable Including wild fruits, 100% fruit juice made from this.
6.	Eggs	From chicken, duck, guinea fowl or any other eggs.
7.	Flesh food Meat, Fish, Poultry and liver organs	Liver, kidney, heart and other organ meats and blood-based foods. Beef, pork, lamb, goat, rabbit, game, chicken, duck, other birds and insects Fresh or dried fish

SECTION 6. DIETARY INTAKE-24 hour recall

Please describe the foods and drinks taken during the last 24 hours from morning to night time whether at home or outside the home.

(Researcher to list all foods mentioned, where composite meals are mentioned probe for the ingredients, when respondent is through probe for any meal that might not have been mentioned.)

Match the meal according to time given by the respondent. NB: ***where the household has more than one child2-5 years old, randomly select one****.*

Time (Breakfast, midmorning snack, lunch etc.)	**Dish**	**Ingredients**	**Amount**	**Total volume of food prepared**	**Unit in grams**	**Amount served to the child (2-5 years)**	**Amount left over**	**Amount consumed**

Section 7: Nutritional status of the child

26. Age (months) =

27. Weight=

28. Height=

29. Presence of physical signs of protein energy malnutrition

1=yes

2=no

NB*: check for the following symptoms and indicate with a tick the signs observed*

1. Edema

2. Dry/peeling skin

3. Hair discoloration

4. Abdominal distention

5. Excessive loss of muscle and tissue

6. Loss of appetite

7. Loose skin

Appendix 3: Data analysis Matrix as per the objectives

Specific objectives	Variables/indices /indicators	Initial processing	Basic statistics	Advanced statistics	Statistical analysis package used
1. To establish the socio-demographic characteristics of the study population	Age Sex Income Gender Education level Land ownership	Cut off point>1 US. dollar/person/ Day	Means Frequency Percentages	Chi square	SPSS
2.To determine the dietary diversity of children 2-5 years in Migori County	Food groups i.e. Proteins Fats Carbohydrates Minerals	≥4 food groups/person/ Day	Frequency Means Percentages	Chi square Regression Correlation	SPSS
3.To determine the amount of dietary energy and protein obtained from cassava by the children 2-5 years in the study County	Cassava consumption patterns	RDA for protein, 2-5 years is 22-25 g/ day	Mean Frequency Percentage	Chi square	Nutri-survey
4.To determine protein and cyanide content of raw cassava flour and Ugali product consumed in the study area **Measurements** Sample weights, chemical ratios for preparations	Protein Cyanide	Maximum cyanide level = 10mg/kg	Means Percentages		Genstart
5.To assess nutritional status and morbidity pattern of children 2-5 years in the study region **Measurements** Weight, Height, Age and Sex	HFA WFA WFH MUAC	Cut off points <-3.00 SD (severe) <-2.00 SD(global)	Frequencies T-test	Chi square Regression Correlation	ENA for SMART