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CONTRIBUTION OF CASSAVA AND CASSAVA-BASED PRODUCTS TO FOOD AND NUTRITION SECURITY IN MIGORI COUNTY, KENYA

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ABSTRACT

The promotion of cassava as a staple and food security crop is widespread in Africa, Kenya included. Overreliance on cassava as a sole energy provider could lead to malnutrition. Consumption of high hydro-cyanide levels from cassava products could lead to health complications for consumers. This study sought to establish the contribution of cassava consumption to nutrition in Migori County. A cross-sectional survey was carried out and data collected on households' cassava production and consumption practices. Two hundred and fifty-three households were randomly selected and household farming heads interviewed in West Kanyamkago, Orango Central and Kamgundho locations as areas where cassava is predominantly grown. Seven cassava flour samples of different cassava varieties grown in the area were obtained from farmers. Analyses were done to determine the moisture, cyanide and protein contents on flour and cooked stiff porridge (*ugali*). Results indicated that 99.1% of the households were farming. They highly depended on sale of farm and livestock produce as income. Ninety four percent of the households consumed cassava, of which 88.4% produced cassava on their farms. The most preferred cassava variety was 'Rateng'. The main cassava products consumed were *ugali* (stiff porridge) and porridge. Majority of the households (95%) never consumed cassava leaves and were not aware that cassava leaves could be consumed. The cyanide level on average on dry flours was 53.23 mg/kg while on consumed cooked ugali was 13.44 mg/kg. These levels were above the maximum limit of 10 mg/kg recommended by WHO. Low average protein levels of <0.5 g/100 g were observed in the cooked ugali. This could pose a danger of protein energy malnutrition if no other sources are consumed by the household members. Cassava farming households in the study area require support to promote growth of low cyanide varieties in order to reduce intake.

Key words: Hydrogen cyanide, Purposive sampling, Households, Diversification, Malnutrition, Consumption

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INTRODUCTION

Cassava (*Manihot esculenta* Crantz) has its origin in Latin America where it has been grown by the indigenous Indian population for at least 4000 years [1]. After the discovery in the Americas, European traders took the crop to Africa as a potentially useful food crop [1]. Nigeria is the largest producer of cassava in the world [2]. It produces about 45 million metric tons and its cassava transformation is the most advanced in Africa [3]. In Kenya, cassava is the second most valued root crop after Irish potatoes and grown throughout Kenya [4]. However, the highest production is in the Western, Coastal and semi-arid (Eastern) regions. The major traditional cooking and consumption pattern in Kenyan households is boiling of fresh roots and roasting [5].

In Western Kenya, processing of cassava roots involves peeling, grating into smaller pieces, fermenting, sun-drying and then milling. The flour is used to cook ugali paste or uji. Cassava production in Kenya is mainly for human consumption after processing into various forms, while surplus is sold either at home or in the local market [3]. As much as there is intensive promotion of cassava growth and consumption as a food security crop by the government of Kenya, little has been achieved in some cassava growing areas. Challenges include human deaths due to high levels of toxic hydrogen cyanide, unavailability of capital resources in rural areas, unavailability of high yielding cassava varieties, and lack of markets.

Despite the energy benefit of cassava, consumption of high hydrogen cyanide cassava varieties would pose health risks to the consumers; low protein levels without a substitute would result in malnutrition among children less than five years of age. This survey sought to identify cassava varieties grown, how they are consumed and their contribution to cyanide and protein intake in Migori County of Kenya.

MATERIALS AND METHODS

Study area

Migori County is one of the 47 counties in Kenya. It is situated in the southwestern part of Kenya, neighboring Homabay, Narok, Kisii counties, Tanzania and Lake Victoria. It has a population of 917,170 with a density of 353 people per square kilometer of which 45% live below one dollar per day [6]. A cross-sectional survey was carried out in West Kanyamkago, Orago central and Kamgundho locations within Migori County, in June-September 2018.

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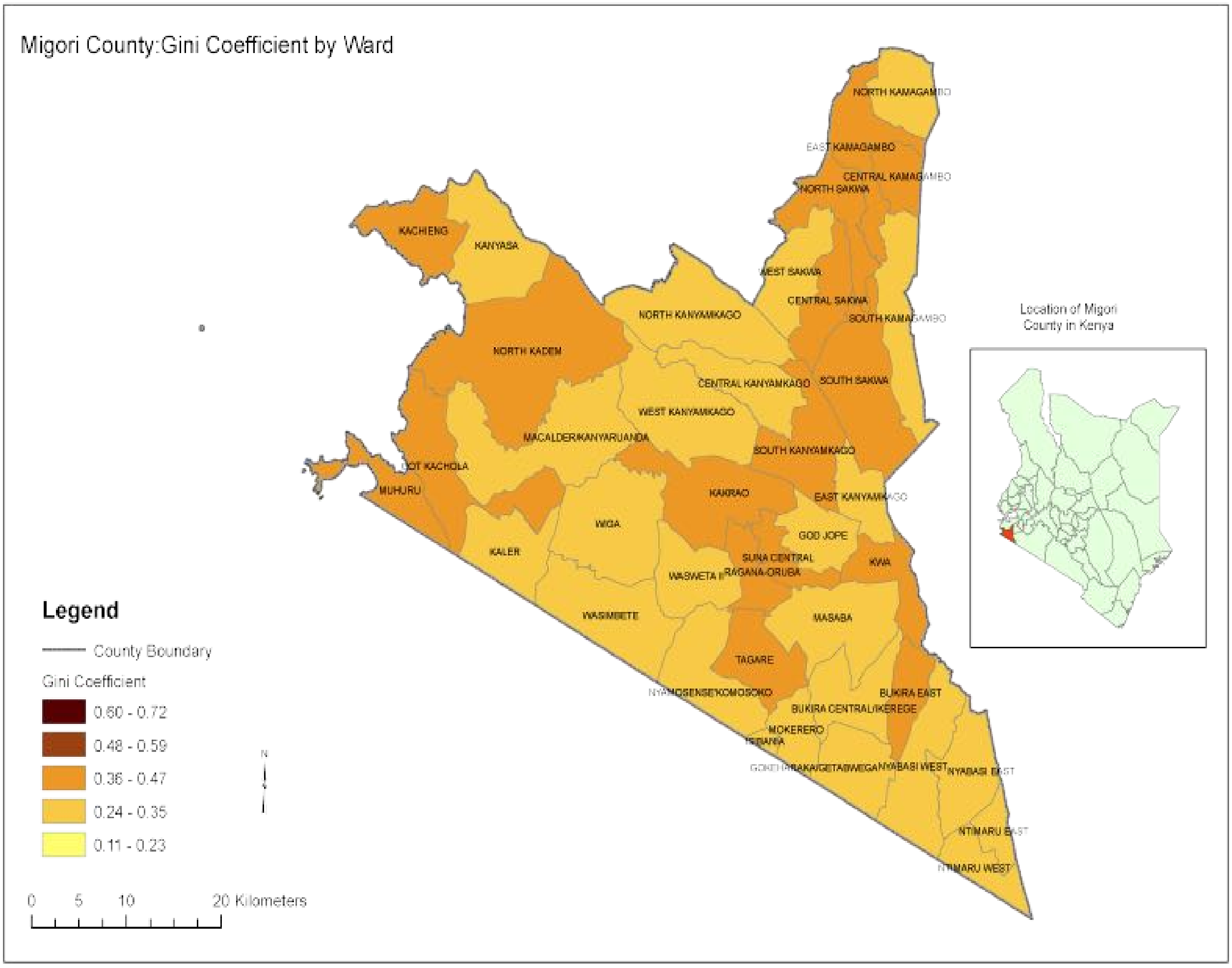

Figure 1: Migori County map by Wards. Source; Gini coefficient maps (2015)

Research Design

The study design was cross-sectional with both descriptive and analytical components to meet various goals. Surveys established cassava production practices together with other qualitative data.

Determination of protein and cyanide contents of cassava flour and cooked ugali was done through Kjeldhal distillation and silver nitrate titration methods, respectively as described in AOAC [7]. All cassava varieties grown in the area were identified and formed the total samples analyzed.

Sampling size determination

The sample size was determined using Cochran's formula [8], as follows:

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

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% [6]
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%

Therefore,

$n= (1.96^2 x 0.914 \times 0.086)/ 0.05^2) =121$ households
4% attrition= (104×121)/100 = 125.84
n = 126 households per location
2 locations sampled in Migori County
n= 2(126) households
n=252 households

Sampling households
Nine villages formed the basis of the purposive sample. These areas were selected because they were accessible and residents highly produced and utilized cassava as their main source of energy. A total number of 252 household farmers were selected through simple random sampling and underwent face-to-face interviews. Semi-structured questionnaires were the main tool to assess the distribution of farming activities; sources, forms, and varieties of cassava consumed; dietary patterns; and consumption disturbance and reasons for disturbance.

Sampling of cassava flour and cooked product
All the various types of consumed cassava flour from different varieties in the study area were sampled from the households, packaged in gunny bags and transported to the University of Nairobi food chemistry laboratory for analysis. Sampling was done by mixing 100 grams of each variety from 10 different household farmers to obtain a representative sample. Measures were taken to prevent moisture absorption. Cooking of ugali was carried out assimilating common practice in the study area.

Preparation of stiff porridge (Ugali)
Stiff porridge was prepared by pouring water into a sufuria (metal pot) and boiling over a medium fire. Flour was added to the boiling water slowly and stirring with a cooking stick to a thick paste with no lumps. The ratio of water to flour was 2:1. Analysis was then carried out to determine the cyanide and protein contents of the flours and ugali samples.

Analytical methods
Determination of crude protein content
Protein was determined using method 14.068 of AOAC [6]. A gram of the sample was digested with 20 ml concentrated H_2SO_4 in the presence of copper and sodium sulphate catalyst and diluted to 100 ml with distilled water. An aliquot of the digest was mixed with 40% NaOH and distilled with Kjeldahl distillation unit into 25 ml of 0.1 N HCl containing 3 drops methyl red indicator. About 200 ml of the distillate was titrated against 0.1 N NaOH solution. A blank containing only the reagents was similarly distilled and titrated and the titer value subtracted from that of the sample. Protein factor of 6.25 was used to convert % nitrogen to % crude protein.

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Determination of cyanide content

Cyanide content was determined using method number 4.093 of AOAC [7]. This was done by weighing 10 g sample in micro-Kjeldahl flask then added 100 ml distilled water 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 250 ml conical flask containing 25 ml of 2.5% (w/v) NaOH solution and titrated with 5% potassium iodide solution.

Data Analysis

Statistical Package for Social Scientists (SPSS) version 20 was used to compute descriptive statistics, establish correlations between different variables, and compare means. Chi square tests were done for cassava consumption patterns in comparison to the locations. Determinations of protein and cyanide contents were analyzed using Genstat analysis software.

RESULTS AND DISCUSSION

Cassava sources and consumption patterns

Ninety four percent (94%) of the households consumed cassava of which 88.4% produced cassava for their own consumption (Table 1). About 11.8% purchased the cassava they consumed, while 6% of the households did not consume cassava. Source of cassava was significantly (Chisquare = 9.23, $P<0.05$) 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%).

Form and source of cassava consumed

The association between the form of cassava consumed (chisquare=32.44, $p<0.005$), and the variety of cassava consumed ($p<0.005$) both varied in a statistically significant way with 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 compared with 50% from Kamgundo (Table 2).

The most preferred cassava varieties in west Kanyamkago were Rateng', Obarodak and Exotic at 83.4%, Orango central cultivated Rateng' and Rapado at 96.5%, while Kamgundho households cultivated Obarodak and Rapado varieties at 94.2% (Table 3).

Disruption in the continuous consumption of cassava products

In total, about three out of ten households stopped consuming cassava at a given time (Table 4). Their reasons for disturbance of cassava consumption were similar with a statistical significance (P=0.341) across the three locations (Table 4). The major reasons were low yield due to disease attack and lack of capital for cassava farming (Figure 2).

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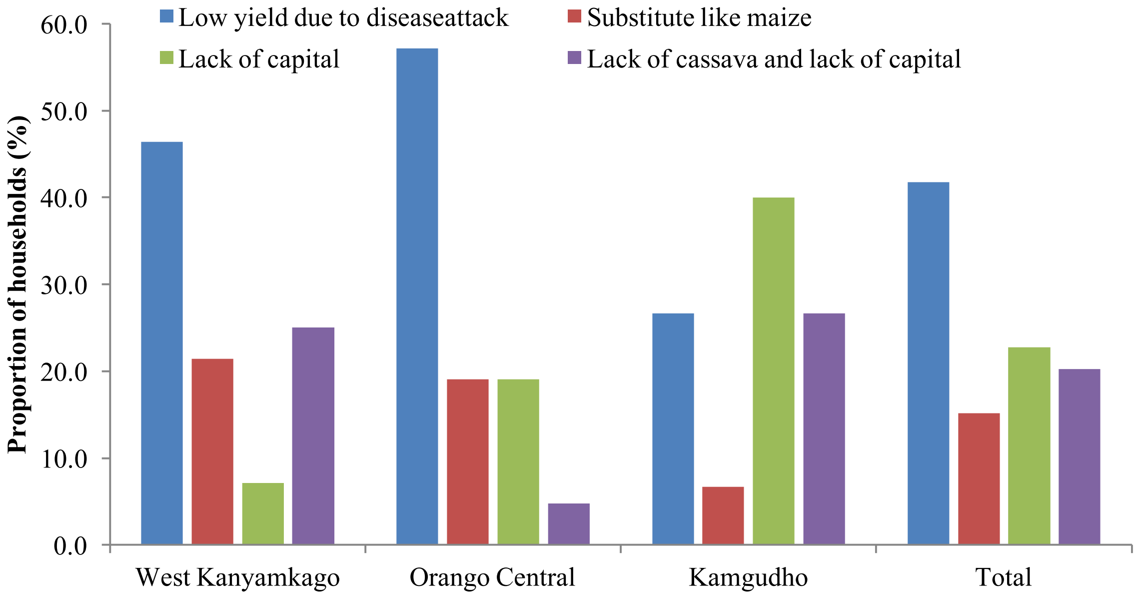

Figure 2: Reason for disturbance of consumption of cassava among households in Migori County

Consumption of cassava leaves in the study area

The association between cassava leaves consumption and locations was statistically significant (chisquare=12.03, $P<0.05$). In West Kanyamkago, 94.8% had never consumed cassava leaves, 98.6% in Orango Central and 95.2 % in Kamgudho (Table 5). The low consumption of cassava leaves was attributed to various perceptions. About 33.6% of the households 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 Figures 3 and 4.

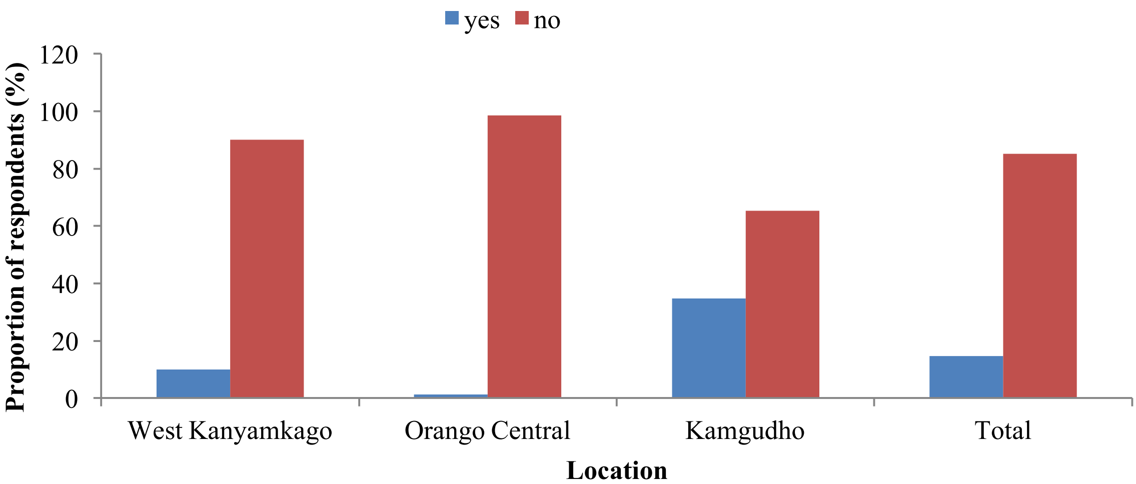

Figure 3: Proportion of respondents with knowledge that cassava leaves are edible across the locations

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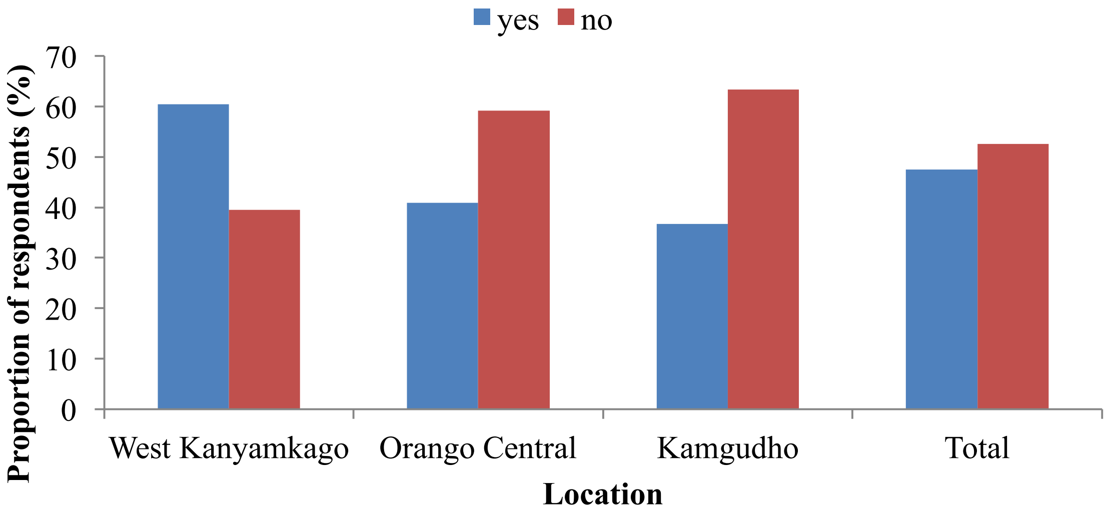

Figure 4: Willingness to consume cassava leaves among those who "don't consume"

Protein and cyanide contents 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 the highest. High cyanide content was recorded in two varieties, Exotic (72.3 mg/Kg) and Raten'g (74.9 mg/Kg) as shown in Table 6.

The most preferred cassava cooked and consumed product in the study area was ugali. Both the protein and cyanide levels decreased in 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 was less than 0.5%, whereas the cyanide levels reduced to < 20 mg/Kg (Table 6). Only two products had cyanide of 10 mg/kg or below as recommended by WHO [9].

Cassava utilization by the study population

Almost all households consumed cassava with majority obtaining it from their own farm. This finding is similar to the study done in the coastal region where (98%) of the households consumed cassava by Nginya [10]. The community highly values cassava as their main food reserve, taking note that it grows well in adverse weather conditions, especially in West Kanyamkago. Consumption of cassava necessitates production of high-quality cassava products [11].

The main consumed cassava products in Migori County are fermented porridge and ugali. A study done in Nigeria on the utilization of cassava for food revealed that, the crop is basically made into fermented and unfermented products. Fermented products include cassava bread, flour, starch, fufu, lafun, akyeke (or attieke), agbelima, and gari

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[12]. As much as traditional mechanisms were used in processing roots into flour, this seems to have promoted longevity in terms of shelflife when selling the product. Draining of the wet chopped cassava helped in facilitating quick sun drying and reduction of hydrogen cyanide, which is harmful to human health. Cynogenic glycoside contained in cassava is hydrolyzed to toxic hydrogen cyanide HCN when consumed in the body [13]. Majority of the consumers sold dry processed cassava chips 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 in dry form. It, thereby, played a role in the communities' economic income and food security.

Despite the fact that cassava leaves have a lot of protein, vitamin A and minerals, almost none of the households consumed them. The majority were not aware that they are consumed and if they were aware, they did not consume them because of the perception of harm. This could be due to availability of other vegetables like kale, cowpea, and traditional leaves. A study in the coastal region revealed both roots and leaves were consumed by the majority of households [11]. Likewise, in Congo and Tanzania, cassava leaves are a very important consumed vegetable and farmers usually prefer cassava varieties with large leafy canopies [14].

The most preferred cassava varieties were Raten'g and Obarodak and this was attributed to their resistance to diseases and high yield. Research institutions should introduce new varieties that are fast growing and disease resistant as observed in the coastal region. The varieties available are traditional with no consistent variety differentiation and naming.

Protein and cyanide contents of cassava flour and stiff porridge (ugali) from Migori County

The cassava varieties grown in the study area are about seven, the main ones being Obarodak and Rateng'. The varieties are basically traditional with the exception of the exotic variety from Kenya Agricultural Livestock and Research Organization (KALRO). It was established that the cyanide levels in dry flours was 53.23 mg/kg, while in consumed cooked ugali was 13.44 mg/kg. These levels are above the limit of 10 mg/kg of dry flour [15]. This means that there are risks of negative effects of consuming high levels of HCN especially in long-term utilization [16]. This explains why the most consumed cassava products were ugali and fermented porridge because other products like boiled cassava roots and crisps would be bitter. Reduction of CN levels of cassava flours to their respective cooked Ugali products was realized. This was to an average of about 60% of all the grown analyzed varieties. This finding agrees with the literature studies that reveal that cooking of cassava flours reduces the amount of cyanide levels [17]. 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 the reduction [18]. As the food is heated, evaporation enables reduction of cyanide content (approximately 100%) for suitable and safer consumption [19].

It was established that the protein content of both cassava flour and cooked ugali were extremely low. This poses the risk of malnutrition especially to children of 2-5 years if other avenues of protein are not realized. The protein levels are similar to the results obtained in the coastal region of Kenya [11]. Low protein and high cyanide increase chances of acute and chronic toxicity, hence protein in the body acts as a major substrate required in the body to break down cyanide [20].

CONCLUSION

The study established that cassava was grown and consumed in almost all households in the form of fermented porridge and ugali. It was the major starchy food, relied upon as a food security crop. The varieties grown were the traditional ones with high hydro-cyanide levels classified as bitter cassava. There was underutilization of other cassava products especially leaves despite their being rich in protein, vitamins and minerals. Sensitization and introduction of the various nutritive cassava products should occur in the area.

The traditional methods used in processing cassava roots into flour and then cooking into porridge and ugali lead to the reduction of cyanide contents. However, cyanide levels were still higher than the recommended levels for human consumption.

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Table 1: Cassava consumption in Migori County

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 (9.23)
No	3.1	13.3	2.5	6.0	

Table 2: Form of cassava consumed in Migori County

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

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Table 3: 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	

Table 4: 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)**

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Table 5: Consumption of cassava leaves in Migori County

cassava leaf consumption	Location (%)			Total (%)	P-Value (χ^2)
	West Kanyamkago	Orango Central	Kamgudho		
Yes	5.2	1..4	9.0	**4.8**	**0.017**
No	94.8	98.6	91.0	**95.2**	**(12.03)**
Preparation method of cassava roots					
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 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**	

Kasumba means cassava leaves preparation that involves boiling then adding milk and salt for consumption

Table 6: 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 $p<0.05$

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