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# THE USE OF CASSAVA LEAVES AS FOOD AND MEDICINAL HERBS IN RURAL COMMUNITIES AND THE PERCEIVED HEALTH RISKS

**O. T. OKAREH[1*], T. A. AJAYEOBA[2], O. F. UGBEKILE[1] AND T. B. HAMMED[1]**

[1]Department of Environmental Health Sciences, Faculty of Public Health, College of Medicine, University of Ibadan, Ibadan, Nigeria.

[2]Department of Microbiology, Faculty of Natural Sciences, Adeleke University, Ede, Osun State, Nigeria.

Email: dapsy2001@yahoo.co.uk

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**ABSTRACT**

The consumption of low cyanide content is not lethal but long-term intake could cause severe health problems. This study assessed the cyanide levels, proximate composition, perception and consumption pattern of cassava leaf varieties in three communities in Southern Nigeria. Fresh cassava leaf samples (TMS 01/1368, Meotoré, B693, Jokojéu, TMS 30572 and a local variety) collected from six designated farms were analyzed for free, total and bound cyanide content and questionnaires were administered to gather information on demographic features of residents, pattern of consumption, knowledge of cyanide related symptoms, diseases or benefits, and perception of its use as food. Besides the average high moisture content of the cassava leaf samples (65.66±1.31), the mean values of crude protein (27.07±0.70) and fibre (13.48±0.23) were higher than fat (7.85±0.38) and ash (8.38±0.66) contents. Fresh tender leaves showed higher cyanide values than the older leaves. The mean age of respondents who consumes the leaves was 41.5±11.1, 53.6% were farmers and 76.1% were married; while 55.6% had at least primary education. Respondents (97.1%), reported using younger tender leaves to cook, 75.5% reported using any variety to cook (regardless of the cyanogenic nature) and 48.9% used cassava leaves for herbal preparations. Farmers (86.6%) had experienced ill-health after consuming improperly processed leaves, but 15% have had a goiter family history. There are risks of cyanide related diseases / poisoning due to extensive consumption of various cassavas improperly processed leaves. Therefore, an urgent intervention is needed to protect the health of the consumers of the leaves.

Keywords: Cassava leaf consumption; cyanide content; cyanogenic nature; goiter; health risk.

## INTRODUCTION

Cassava (*Manihot esculenta Crantz*) is widely cultivated for its roots, but the leaves have been consumed in various parts of African including Indonesia, Philippines Malaysia, Senegal, Mozambique, Tanzania, Kenya, Malawi, Madagascar, Zaire, Congo, Tanzania, Sierra Leone, Nigeria and Guinea [1]. Many authors have stressed the nutritional value of cassava leaves and promoted their use as a source of protein and vitamins in the diet of people in tropical regions, but it also has toxicity due to cyanogenic glucosides and other anti-nutritional factors that decrease nutrient bioavailability, nutrient uptake, and digestibility, causing different diseases, but the toxic effects depend on the processing method and amount consumed [1,2]. While studies have shown that cyanogenic glycoside levels are usually lower in cassava

roots than in leaves and stems, type of cultivars, climatic conditions during growth, and fertilizers used can affect the cyanide content of cassava [3].

Goiters are a relatively common disease in Nigeria [4] with an occurrence that varies from one part of the country to another, just as different countries on the continent of Africa have different rates, with different possible etiologies being postulated [5]. Although the lack of salt iodization has been reported as a major cause of goiter, the key causes of iodine deficiency disorder are insufficient amounts of iodine in the body, which can also be due to diets low in iodine [6]. Edo State in Southern Nigeria is one of the major locations mapped out as a goiter endemic area [7]. While there are goals in place intended to reduce the lack of iodization of salt [8], constant attention is required for frequent assessment. Despite these targets, studies have shown that goiter incidence has not significantly decreased over time [9]. Besides, 90% of school children have exhibited moderate to severe iodine deficiency, as measured by urinary iodine excretion [7], which has been attributed to lack of education, poor handling of food products, thus leading to iodine deficiency. Goiter and cretinism due to iodine deficiency can be exacerbated by chronic consumption of insufficiently processed cassava.

The consumption of lower cyanide amounts is not lethal, but long-term intake could cause severe health problems such as tropical neuropathy and glucose intolerance [10]. Occasional cases of the sudden death of families have been recorded after taking a cassava meal containing a lethal dose of cyanide due to poor processing [11]. The Afemai tribe of the Edo State and its environs in the Southern part of Nigeria, where this study was carried out are mostly peasant farmers [12], whose major occupation is subsistence farming, including cassava processing. Cassava leaves also come as a cheap protein source for them because it is readily available as they collect them from their farms at no cost. Therefore, there is a need to determine the cyanide content in cassava leaf varieties and assess the consumption patterns, including the knowledge, perception, and attitude of the exposed population in the selected communities on the dietary consumption of cassava leaf as vegetables/herbs, relating it to the associated health risks.

## MATERIALS AND METHODS

### Description of the Study Area

The study area for this research was OELGA in Edo state, Nigeria. It lies between Latitude 6° 47′ 0″ north of the equator and Longitude 5° 49′ 0″ east of the Greenwich Meridian with an area of 1,240km$^2$ and its headquarters in Afuze. It comprises Afuze, Otou, Uokhai, Oviobumu, and Ake among others, who are Afemai by tribe [13]. The locations of the communities are as shown in Fig. 1. These communities were chosen because of their population, extensive farming activities, and the existence of peri-urban and urban vegetable production. They are mixture of Christians, Muslims, and traditional religious practitioners.

### Study Design and Scope of Research

A cross-sectional descriptive design with laboratory-based component was conducted among the Afemai people, who are scattered around the Owan River and bounded to the south by Erah, to the west by Ora, to the east by Ihievbe, and to the north by Uokha and Ake. The Afemai people occupy the towns of Uanhumi, Ovbiwun, Afuze, Eteye, Ogute, Evbiamen, Evbiamen Ugboha, Okpohunmi, Ojavun, and Ojavun-

Ago. A 4-stage sampling method was employed in this study. Firstly, Owan East Local Government Area (OELGA) in Edo State, Southern Nigeria was purposively selected for this study. Secondly, a simple random sampling, involving balloting was used to select three communities known to commonly consume the cassava leaves for food. They include Uanhumi, Ogute, and Evbiamen. The estimated sample size for the study was 180 respondents. Thirdly, the numbers of respondents to be interviewed per community were selected by stratified sampling method, based on community population size (proportional allocation). Using the formula for the sample size determination ($n = Z^2pq/d^2$) [14] where n is the sample size, p is the estimated proportion of interest (0.5), d is the standard error (0.05) while $Z^2$ of 1.96 at 95% confidence level and a precision of 5%, a minimum sample size of 163 was calculated. After correcting for 10% non-response, the final sample size of 180 was used in the study. Participants (mothers and young/adolescent girls) were targeted because they know the frequency of consumption, different processing/cooking methods, and are also saddled with the preparation of family meals.

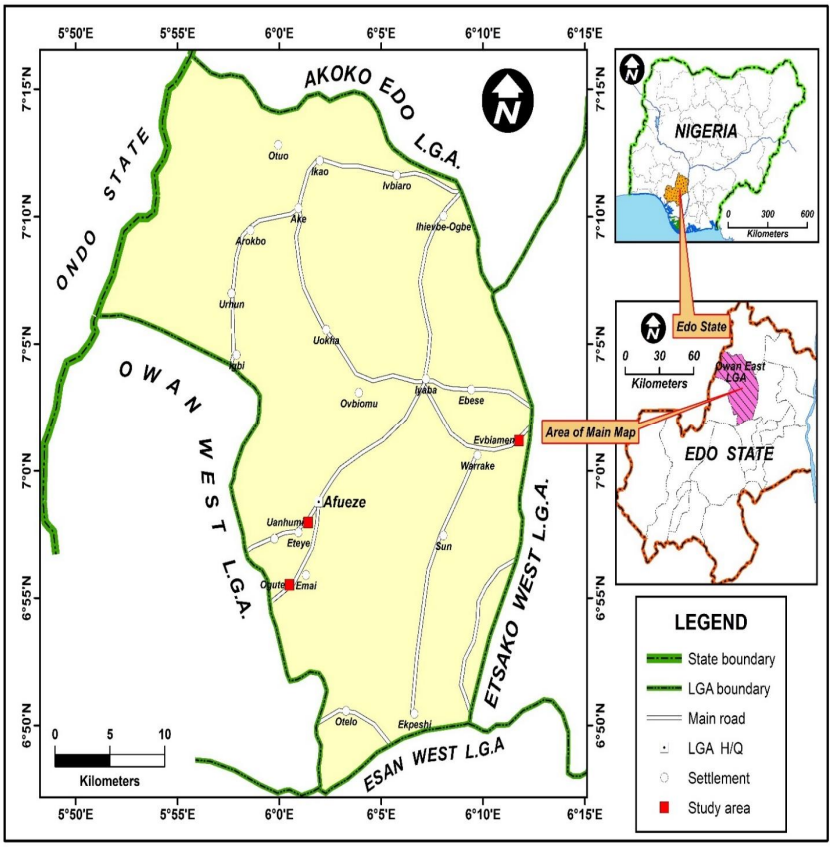


**Fig. 1. Map of Owan East Local Government Area (OELGA) with the Selected Communities**

From information obtained from community heads, the number of houses was estimated and counts were made. Stratification was carried out and the number of households selected was calculated as follows using N= (W/T) x SS where N= Number of households selected for each area, W= Number of households in each community, T= Total number of households in the selected communities, and SS= Total sample size of households.

**EVBIAMEN:**

$$N = \frac{W}{T} \times SS = \frac{54}{444} \times 180 = 35$$

A total of 35 households were randomly selected from Evbiamen

**OGUTE:**

$$N = \frac{W}{T} \times SS = \frac{152}{444} \times 180 = 54$$

A total number of 54 households were selected from Ogute (Every third household)

**UANHUMI:**

$$N = \frac{W}{T} \times SS = \frac{208}{444} \times 180 = 69$$

A total number of 69 households were selected from Uanhumi (Every second household).

**Inclusion Criteria**

The participant must be either one of the heads of the household or responsible for preparing family meals. Only residents and indigenes within Owan East LGA were selected for the study.

**Validity of Questionnaire**

Several measures were taken during the pre-test to ensure and improve for precision, clarity, and correctness of the instruments. The instrument was pre-tested in a community in another local government area that has similar characteristics with the study communities, but was not included in the study. A total of 18 residents were involved in the pre-test. Such corrections include the addition of some questions and removal of irrelevant ones and identification of Interview time. During the pre-test exercise, the best time to interview the respondents was noted and that was the interview time employed for this research.

**Reliability of the Questionnaire**

The reliability of the questionnaire was determined by subjecting it to its measures of internal consistency with the use of Cronbach's alpha coefficient analysis. A correlation coefficient greater than 0.05 is said to be reliable. In this study, the result was 0.744, which is greater than 0.05. This shows that the instrument has a good degree of reliability. To do this, the pre-test questionnaire was coded and entered into a computer before analysis. The perception was carried out on a nine-point scale, point ≤4 was considered poor while >4-9 was considered good.

**Questionnaire Survey and Administration**

Research assistants were trained on the data collection process, consistency, proper completeness of data, and interpreters were used for respondents who do not understand English. The questionnaire was structured into sections to provide information on socio-demographic information of residents, vegetable supply and pattern of consumption, cassava leaf

use pattern, health knowledge /perceived incidence of cyanide related toxic effects of consumption, perception of the use of cassava leaves in medicinal herbs preparations and awareness of health benefits (supplementary file). Administered questionnaires were used to elicit information from residents on their knowledge, perception, and attitude towards the use of cassava leaves as vegetables and for medicinal herbs preparation. The majority of the residents were interviewed in the evenings.

### Ethical Consideration

Written consent (written and verbal) by the participants was the basis for participation in the research. Participation was voluntary and there was no coercion of participants who refused to participate. Also, assurances of confidentiality of participants' responses were maintained during and after administration of the questionnaires. Names of the participants were not obtained on the questionnaires to ensure anonymity.

### Laboratory Analysis

### Chemicals and standards

All reagents and consumables used were of high purity (99.99%) and analytical grade.

### Determination of the proximate composition of cassava leaves

The proximate analysis and cyanide analysis of younger and older cassava leaves were analyzed according to methods used by [15].

### Statistical Analysis

Data from filled questionnaires were analyzed using Statistical Package for Social Sciences v22. Variables were represented in frequency, percentages, mean, and standard deviation respectively. Bivariate analysis using Chi-square was used to establish an association between socio-demographic and other related characteristics. The logistic regression model was used to determine possible socio-demographic and other related predictors of cassava leaf. Independent variables in the bivariate analysis with p-value ≤ 0.2 were entered into the initial univariate analysis (model1) to calculate crude ORs with 95% confidence interval. Demographic and health-related characteristics whose p-values were less than 0.05 in the univariate analysis were entered into the multivariable analysis (model 2) to determine adjusted odds ratios. We considered covariates in the multivariate model as an independent predictor(s) of herbal medicine use if its p-value was less than 0.05.

## RESULTS

### Socio-demographic Characteristics of the Respondents

The socio-demographic characteristics of the respondents are shown in Table 1. A total of one-hundred and eighty community members in the selected communities in the study location were interviewed. Respondents, 174 (96.7%) were females with a mean age of 41.5±11.1 years, 137 (76.1%) were married and 175 (97.2%) were Christians. More than half (55.6%) had secondary education. Based on ethnic group distribution, most respondents were Edo indigents, 168 (93.3%) with a high proportion, 39 (21.6%) having more than four children. The occupation of the respondents showed that 97(53.9%) were farmers, professionals 25 (13.9%), traders 13(7.2%), self-employed 29(10.6%), students (17%) and 9 (5.0%) were artisans.

**Table 1. Socio-demographic characteristics of respondents**

| Variables | Frequency n=180 | Percentage (%) | Mean ±SD |
|---|---|---|---|
| **Age** | | | |
| 22-32 | 41 | 22.8 | 41.5±11.1 |
| 33-42 | 70 | 38.9 | |
| 43-52 | 38 | 21.1 | |
| 53-62 | 21 | 11.7 | |
| >62 | 10 | 5.6 | |
| **Gender** | | | |
| Male | 6 | 3.3 | |
| Female | 174 | 96.7 | |
| **Marital status** | | | |
| Single | 25 | 13.9 | |
| Married | 137 | 76.1 | |
| Divorced | 3 | 1.7 | |
| Widowed | 15 | 8.3 | |
| **Religion** | | | |
| Christianity | 175 | 97.2 | |
| Islam | 5 | 2.8 | |
| **Educational status** | | | |
| No formal education | 8 | 4.4 | |
| Primary | 50 | 27.8 | |
| Secondary | 100 | 55.6 | |
| Tertiary | 22 | 12.2 | |
| **Ethnic group** | | | |
| Yoruba | 1 | 0.6 | |
| Igbo | 11 | 6.1 | |
| Edo | 168 | 93.3 | |
| **Number of children** | | | |
| 1 | 9 | 5.0 | 3.6±1.7 |
| 2 | 38 | 21.1 | |
| 3 | 35 | 19.4 | |
| 4 | 32 | 17.8 | |
| >4 | 39 | 21.6 | |
| Unwilling to respond | 27 | 15.0 | |

**Use of Cassava Leaves and Pattern of Cassava Consumption among the Respondents**

Although all the respondents have ever eaten a cassava product (Table 2), only 83.3% have ever eaten cassava leaves. The majority 135 (97.1%) of the respondents reported using younger, tender leaves to cook while about 75.5% used a different variety of the cassava leaf, based on availability. Respondents (75.6%) reported using cassava leaves to cook soup and 67.6% reported having excellent experience with the use of the cassava leaves. About 51(36.7%) of the respondents that cooked

with it, do so once in two weeks. The majority (73.9%) reported that the cassava leaves were highly available for use, while all reported cooking with the leaves using the stewing method. Respondents (9.4%) reported that they normally use the sautéing method, while 6.7% boiled the leaves in a liquid medium. Respondents (46.8%) reported that they use 30 min to 1 hour to prepare the cassava leaves on their own or with food, 30.9% reported cooking for 10-30 min while 4.3% cook for < 5 minutes. For the frequency of cassava leaf usage among respondents, 77(55.4%) often use the leaves to cook, 56 (40.3%) rarely do, while 6 (4.3%) uses the leaves to cook always.

**Use of Cassava Leaves in Medicinal Herbs Preparations, Protein Supplements and Method of Preparation among Respondents**

Table 3 shows that most (92.8%) of the respondents have ever taken herbal preparations and 48.9% have taken cassava leaf-based herbal preparations. More than a quarter (39.8%) of them has taken the preparation 2 to 5 times. About 60.0% have ever prepared any herbal medicine with cassava leaves as the combination, and all (100.0%) of them have prepared it using the boiling method. The majority (75.0%) used 30 minutes to 1 hour to prepare the herbs and 67.1% reported an improvement in their health after taking the herbs. The various preparation methods employed by the respondents for the cassava leaf-based herbal medicinal preparations are presented in Fig. 2. Respondents, 72(100%) reported boiling, 22(30.6%) take or apply the leaves raw while 14 (19.4%) soak in alcohol (Dry Gin).

About 43.9% are aware of the high protein content of the cassava leaves and none (100.0%) were aware of any toxic substance in it. About 50.6% are aware of the benefits of cassava.

**Perception of the Use of Cassava Leaves in Medicinal Herbs Preparations among the Respondents**

Most (96.1%) of the respondents disagreed with the use of cassava leaves alone for their antioxidants properties without using other drugs while 63.9% disagreed with the preference of cassava leaves over other vegetables because they are cheaper. Respondents (13.4%) agreed to the inclusion of cassava leaves in their animal feed, because it is proteinous (Fig. 2). Respondents (23.9%) had the right perception of cassava leaves as medicinal herbs and protein supplements.

**Perceived Prevalence of ill Health Due to Ingestion of Improperly Processed Cassava Leaves among the Respondents**

Table 4 shows that more than one-tenth (16.1%) have ever experienced ill health due to the toxic effect of improperly processed cassava leaves and 45.0% reported that a family member had experienced ill-health from eating improperly processed foods. About 16.1% reported that there had been a goitre case in their family. Less than one-tenth (9.4%) reported that they have had a cancer family history and 52.9% reported stomach cancer as the major cancer type.

**Association between the Perceived Prevalence of ill Health Due to Toxic Effects of Improperly Processed Cassava Leaves and Socio-demographic Characteristics of Respondents**

On the socio-demographic characteristics of respondents, Table 5 shows that there are significant relationships between the experience of illness of

respondents and the age ($p<0.001$) and occupation ($p=0.001$) of respondents because a higher proportion (26.5%) of respondents that are >40 years had illness due to toxic effect of improperly processed cassava leaves compared to those that are ≤ 40 years (7.2%), suggesting that the younger household members who prepare the food may be naïve about the health implications of cassava leaf. Furthermore, since most are predominantly farmers and artisans, the poor educational background may also be a contributing factor to improper understanding of the toxic effect of cassava leaf.

**Table 2. Use of cassava leaves and pattern of consumption among the respondents**

| Variables | Frequency n=180 | Percentage (%) |
|---|---|---|
| **Ever eaten cassava leaves** | | |
| Yes | 150 | 83.3 |
| No | 30 | 16.7 |
| **Ever cooked with cassava leaves** | | |
| Yes | 139 | 77.2 |
| No | 41 | 22.8 |
| **Particular leaf that was been used to cook (n=139)** | | |
| Younger | 135 | 97.1 |
| Anyone | 1 | 0.7 |
| Both young and old | 3 | 2.2 |
| **Use a particular variety of cassava leaves to cook (n=139)** | | |
| Yes | 34 | 24.5 |
| No | 105 | 75.5 |
| **Experience with the use of the leaves (n=139)** | | |
| Excellent | 94 | 67.6 |
| Good | 44 | 31.7 |
| Fair | 1 | 0.7 |
| **Usage of the cassava leaves** | | |
| Used to cook soup | 136 | 75.6 |
| Used in making porridges | 43 | 23.9 |
| Used in making puddings | 1 | 0.6 |
| * **Multiple responses allowed** | | |
| **Availability of cassava leaves (n=180)** | | |
| Highly available | 133 | 73.9 |
| Moderately available | 21 | 11.7 |
| Available | 26 | 14.4 |
| **Pattern of cooking with cassava leaves among respondents** | | |

| Variables | Frequency n=180 | Percentage (%) |
|---|---|---|
| **How often cassava leaves was been used to cook or eat** | | |
| Daily | 1 | 0.7 |
| 2-4 times a week | 22 | 15.8 |
| Once a week | 22 | 15.8 |
| Once in two weeks | 51 | 36.7 |
| Once in a month | 28 | 20.1 |
| Once/twice in two to three months | 15 | 10.8 |
| **Cooking methods for cassava leaves** | | |
| Proportion that reported they employed the stewing method | 139 | 100.0 |
| Proportion that reported they boiled it | 12 | 6.7 |
| Proportion that reported Sautéing | 14 | 9.4 |
| *** Multiple responses allowed** | | |
| **Length of time used to cook cassava leaves either on its own or with another food** | | |
| < 5 min | 6 | 4.3 |
| 5- 10 min | 25 | 18.0 |
| 10-30 min | 43 | 30.9 |
| 30 min – 1 h | 65 | 46.8 |

**Table 3. Use of cassava leaves in medicinal herbs preparations, protein supplements and awareness of the health implications among the respondents**

| Variables | Frequency n=180 | Percentage (%) |
|---|---|---|
| **Ever taken herbal preparation** | | |
| Yes | 167 | 92.8 |
| No | 13 | 7.2 |
| **Ever taken any herbal medicine with cassava leaves** | | |
| Yes | 88 | 48.9 |
| No | 92 | 51.1 |
| **How many times have you taken it (n=88)** | | |
| Once | 2 | 2.3 |
| 2-5 times | 35 | 39.8 |
| 5-10 times | 22 | 25.0 |
| More than 10 times | 25 | 28.4 |
| Don’t know | 2 | 2.3 |

| Variables | Frequency n=180 | Percentage (%) |
|---|---|---|
| **Ever prepared any herbal medicine with cassava leaves as combination (n=180)** | | |
| Yes | 72 | 40.0 |
| No | 108 | 60.0 |
| *** Multiple responses allowed** | | |
| **How long herbs were prepared (n=72)** | | |
| ≤10 min | 4 | 5.6 |
| 10-30 min | 14 | 19.4 |
| 30 min- 1 h | 54 | 75.0 |
| **If health status has improved after taking the herbs (n=72)** | | |
| Yes | 49 | 67.1 |
| May be | 23 | 32.9 |
| **Aware of the high protein content of cassava leaves** | | |
| Yes | 79 | 43.9 |
| No | 101 | 56.1 |
| **Aware of any toxic substance in cassava leaves** | | |
| Yes | 0.0 | 0.0 |
| No | 180 | 100.0 |
| **Aware of the benefits of cassava leaves** | | |
| Yes | 89 | 49.4 |
| No | 91 | 50.6 |

**Table 4. Perceived prevalence of illness due to ingestion of improperly processed cassava leaves, benefits and toxicant in cassava leaves among the respondents**

| Variables | Frequency n=180 | Percentage (%) |
|---|---|---|
| **Experience any ill health symptoms due to the toxic effect of improperly processed cassava leaves** | | |
| Yes | 29 | 16.1 |
| No | 151 | 83.9 |
| **Respondents or family members ever experience illness from eating improperly processed foods** | | |
| Yes | 81 | 45.0 |
| No | 91 | 50.6 |
| Don't know | 8 | 4.4 |
| **Goiter Family History** | | |
| Yes | 29 | 16.1 |
| No | 150 | 83.3 |
| Don't know | 1 | 0.6 |

| Variables | Frequency n=180 | Percentage (%) |
|---|---|---|
| **Cancer family history** | | |
| Yes | 17 | 9.4 |
| No | 163 | 90.6 |
| **Type of cancer (n=17)** | | |
| Stomach | 9 | 52.9 |
| Beast | 6 | 35.3 |
| Lung | 2 | 11.8 |
| **Aware of the high protein content of cassava leaves** | | |
| Yes | 79 | 43.9 |
| No | 101 | 56.1 |
| **Aware of any toxic substance in cassava leaves** | | |
| Yes | 0 | 0.0 |
| No | 180 | 100.0 |
| **Aware of the benefits of cassava leaves** | | |
| Yes | 89 | 49.4 |
| No | 91 | 50.6 |

There are also significant relationships (*p=0.031*) between ill-health due to the toxic effect of improperly processed cassava leaves and perception of the high protein content of cassava leaves among respondents (22.8%) compared to those that are not aware (10.9%), suggesting a public health risk to consumers, if consumption is based on the nutritional aspect without the toxic composition and health effect. However, there was no significant relationship between the experience of illness due to the toxic effect of improperly processed cassava leaves and usage of the cassava leaves.

**Logistic Regression Associations between Experience of Illness Due to the Toxic Effect of Improperly Processed Cassava Leaves and Reference Variables among Respondents**

Among the Logistic regression associations between experience of illness due to toxic effect of improperly processed cassava leaves and variables significant at p< 0.2 in the bivariate analysis, age, occupation, and awareness of the high protein content of cassava leaves were significant predictors of experience of illness due to toxic effect of improperly processed cassava leaves. Respondents that are > 40 years are almost 5 times more likely to have illness due to the toxic effect of improperly processed cassava leaves compared to those that are ≤40 years (OR=4.5, 95% CI=1.8-11.3). Those that are farmers were almost 5 times more likely to have illness due to the toxic effect of improperly processed cassava leaves compared to those that are professionals (OR=0.2, 95% CI=0.1-0.5). Those that are students were almost 5 times more likely to have illness due to the toxic effect of improperly processed cassava leaves compared to those that are professionals (OR=0.2, 95% CI=0.0-1.0). Those that are aware of the high protein content of cassava leaves were 2 times more likely to have illness due to the toxic effect of improperly processed cassava leaves compared to those that are not aware (OR=2.4, 95% CI= 10-5.4) (Table 6).

**Table 5. Association between the perceived prevalence of ill health due to toxic effect of improperly processed cassava leaves and socio-demographic characteristics of the respondents**

| Variables | | Occurrence of illness | | Total | Chi-square value | P-Value |
|---|---|---|---|---|---|---|
| | | No n(%) | Yes n(%) | | | |
| **Demographic variables** | **Age groups** | | | | | |
| | ≤40 | 90(92.8) | 7 (7.2) | 97 | 12.3 | <0.001 |
| | >40 | 61(73.5) | 22 (26.5) | 83 | | |
| | Gender | | | | | |
| | Male | 6(100.0) | 0 (0.0) | 6 | 1.2 | 0.275 |
| | Female | 145(83.3) | 29 (16.7) | 174 | | |
| | Educational status | | | | | |
| | Non formal | 6 (75.0) | 2 (25.0) | 8 | 0.5 | 0.484 |
| | Formal | 145(84.3) | 27 (15.7) | 172 | | |
| | Marital Status | | | | | |
| | Single | 25(100.0) | 0 (0.0) | 25 | 7.1 | 0.069 |
| | Married | 112(81.8) | 25(18.2) | 137 | | |
| | Divorced/Separated | 3(100.01) | 0(0.0) | 3 | | |
| | Widowed | 11(73.3) | 4(26.7) | 15 | | |
| | Ethnic group | | | | | |
| | Yoruba | 1(100.0) | 0(0.0) | 1 | 0.6 | 0.729 |
| | Igbo | 10(90.9) | 1(9.1) | 11 | | |
| | Edo | 140(83.3) | 28(16.7) | 168 | | |
| | Religion | | | | | |
| | Christianity | 148(84.6) | 27(15.4) | 175 | 2.2 | 0.141 |
| | Islam | 3(60.0) | 2(40.0) | 5 | | |
| | Occupation | | | | | |
| | Trading | 3 (23.1) | 10(76.9) | 13 | 20.4 | 0.001 |
| | Farming | 13(13.4) | 84(86.6) | 97 | | |

| Variables | | Occurrence of illness | | Total | Chi-square value | P-Value |
|---|---|---|---|---|---|---|
| | | No n(%) | Yes n(%) | | | |
| | Artisan | 0 (0.0) | 8(100.0) | 8 | | |
| | Student | 2 (11.8) | 15(88.2) | 17 | | |
| | Self-employed | 0 (0.0) | 18(100.0) | 18 | | |
| | Professional | 11(44.0) | 14(56.0) | 25 | | |
| **Cassava leaf usage** | **Ever eaten cassava leaves** | | | | | |
| | Yes | 125(83.3) | 25(16.7) | 150 | 0.2 | 0.650 |
| | No | 26(86.7) | 4(13.3) | 30 | | |
| | Ever cooked with cassava leaves | | | | | |
| | Yes | 114(82.0) | 25(18.0) | 139 | 1.6 | 0.208 |
| | No | 37(90.2) | 4(9.8) | 41 | | |
| | Ever taken herbal medication with cassava leaves | | | | | |
| | Yes | 72 (81.8) | 16(18.2) | 88 | 0.5 | 0.460 |
| | No | 79 (85.9) | 13(14.1) | 92 | | |
| **Awareness/perception of the benefits of cassava leaves** | **Aware of the high protein content of cassava leaves** | | | | | |
| | Yes | 61(77.2) | 18(22.8) | 79 | 4.6 | 0.031 |
| | No | 90(89.1) | 11(10.9) | 101 | | |
| | Perception to cassava leaves | | | | | |
| | Right perception | 36 (87.8) | 5 (12.2) | 41 | 0.656 | 0.418 |
| | Wrong perception | 113(82.5) | 24(17.5) | 137 | | |

**Table 6. Logistic regression associations between experience of illness due to the toxic effect of improperly processed cassava leaves and reference variables among respondents**

| Variables | Odd ratio | 95% Confidence interval | | *P-value* |
|---|---|---|---|---|
| | | Lower | Upper | |
| **Age (years)** | | | | |
| >40 | 4.5 | 1.8 | 11.3 | 0.001 |
| ***** ≤40 | | | | |
| **Marital Status** | | | | |
| Widowed | 1.6 | 0.5 | 5.5 | 0.443 |
| *****Single | | | | |
| **Religion** | | | | |
| Christianity | 3.6 | 0.6 | 22.6 | 0.171 |
| * Islam | | | | |
| **Occupation** | | | | |
| Trading | 0.4 | 0.1 | 1.7 | 0.212 |
| Farming | 0.2 | 0.1 | 0.5 | 0.001 |
| Student | 0.2 | 0.0 | 1.0 | 0.038 |
| * Professional | | | | |
| **Aware of the high protein content of cassava leaves** | | | | |
| Yes | 2.4 | 1.0 | 5.4 | 0.040 |
| * No | | | | |

** Reference variables*

*+ Variables significant at p <0.2 on the bivariate analysis were included in the mode*

**Table 7. Mean values of the proximate analysis and cyanide concentration of different leaf samples**

| Parameters | Cassava varieties | | | | | | |
|---|---|---|---|---|---|---|---|
| | Local variety | TMS 01/1368 | B693 | Meotoré | Jokojéu | TMS 30572 | Mean (x±SD) |
| **Cyanide contents (µg/kg of fresh leaves)** | | | | | | | |
| **Free cyanide** | | | | | | | |
| Tender leaves | 96.47±8.50 | 76.27±9.34 | 102.37±11.72 | 93.20±9.65 | 101.33±10.24 | 93.70±5.94 | 93.89±9.23 |
| Older leaves | 83.30±7.49 | 98.00 ±12.60 | 89.53±22.28 | 42.23±6.46 | 101.70±12.64 | 84.22 ±5.15 | 83.16±11.10 |
| Total cyanide | | | | | | | |
| Tender leaves | 122.43±5.44 | 106.96±12.91 | 115.73±13.81 | 110.40±15.61 | 112.06±10.45 | 97.23±8.25 | 110.80±11.08 |
| Older leaves | 114.46±7.64 | 117.13±6.49 | 111.26±11.05 | 69.3 ±10.04 | 109.33±2.61 | 86.93±1.36 | 101.40±6.53 |
| Bound cyanide | | | | | | | |
| Tender leaves | 25.67±7.15 | 30.70±10.84 | 53.26±13.18 | 17.20±6.10 | 1.73±4.84 | 3.53±2.46 | 22.02±7.43 |
| Older leaves | 31.67±9.28 | 19.13±6.94 | 21.73±16.99 | 22.06±12.83 | 12.43±7.68 | 6.57±4.53 | 18.93±9.71 |
| **Proximate analysis** | | | | | | | |
| Crude protein | 24.05±0.58 | 32.62±1.01 | 36.93±1.25 | 20.27±0.61 | 17.13±0.15 | 31.43±0.57 | 27.07±0.70 |
| Crude Fat | 6.91±0.14 | 10.43±0.56 | 6.34±0.28 | 6.58±0.55 | 8.14±0.16 | 8.67±0.58 | 7.85±0.38 |
| Crude Fibre | 12.07±0.17 | 13.02±0.11 | 16.10±0.85 | 14.93±0.07 | 10.90±0.03 | 13.83±0.14 | 13.48±0.23 |
| Moisture content | 64.39±1.04 | 69.39±1.39 | 65.63±1.58 | 58.05±3.31 | 70.14±2.13 | 66.36 ±1.31 | 65.66±1.79 |
| Ash content | 7.36 ±0.29 | 9.58±0.45 | 7.58 ±0.81 | 10.50 ±1.18 | 7.84±1.04 | 7.396±0.19 | 8.38±0.66 |

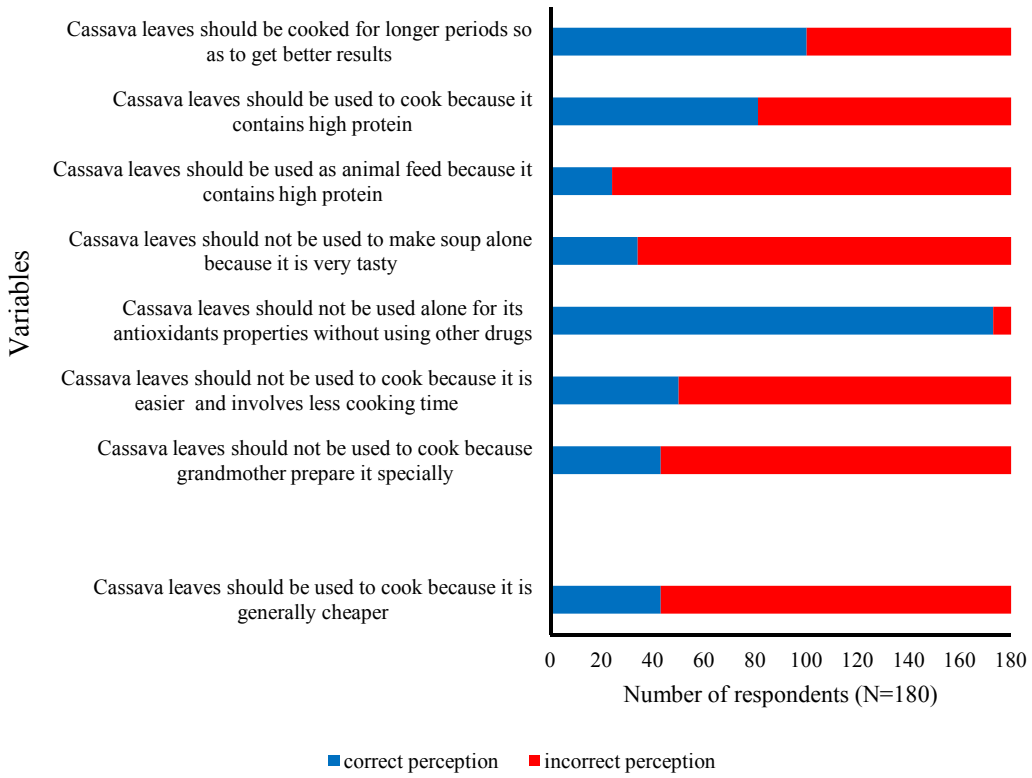


**Fig. 2. Perception about cassava leaves usage in medicinal herbs preparation among the respondents**

The cyanide content (µg/kg) of the cassava varieties are shown in Table 7. Generally, the mean values for the cyanide contents in tender leaves (TL) were higher than older leaves (OL). Although Jokojéu free cyanide content was the highest for both OL and TL (101.33±10.24; 101.70±12.64), the local variety had the highest values of total cyanide content (122.43±5.44) for TL and TMS 01/1368 for OL. However, Jokojéu and TMS 30572 varieties had 1.73±4.84 and 6.57±4.53 mean values for TL and OL respectively. B693 variety had the highest crude protein and fibre (36.93±1.25; 16.10±0.85) while Jokojéu and Meotoré had the highest fat and ash contents (8.14±0.16; 10.50 ±1.18).

## DISCUSSION

The socio-demographic characteristics of respondents in the study population showed that most of the participants were predominantly female, married, indigenes of Edo state in Southern Nigeria, and had up to secondary school education. Poverty and illiteracy have been identified as incapacitating forces among the rural women, who are predominantly farmers and care, plan, and process food for the household [16]. The major occupation, which is farming may be the reason for their access to the cassava leaves since they obtain the leaves at no cost. In addition, cassava cultivation is relatively cheaper,

being drought-tolerant and has ability to do well in less fertile soils. Although the level of anti-nutrients in cassava leaves varies, depending on the maturity status, climate condition and variety of cassava [1], the high consumption of younger leaves observed in this study is a public health threat. This is because, cassava leaves have sufficient levels of hydrocyanic acid, anti-nutrients, low digestible energy and a high content of tannin and phytin, but the crude protein and amino acid levels decrease as the leaf ages, while crude fiber, hemicellulose and cellulose levels increase [17]. There are reports of mortality from eating a cassava-based meal in Nigeria, whose major occupation is farming [18]. However, the high proportion (67.6%) having excellent experience with the use of the cassava leaf and 75.6% using it to cook soup is an indication of the level of acceptability of the leaf for food by the respondents.

Depending on the cultivar and climate conditions, cassava leaves contain a high content of crude protein (17.7–38.1% dry matter basis). It is also high in vitamins, $B_1$, $B_2$, C, carotenoids, and minerals such as phosphorus, magnesium, potassium, and calcium, but low in manganese, zinc, iron, copper, and sodium [1]. The use of cassava leaves for herbal medicine preparations connotes the acceptability and its use as an alternative therapy. Cassava leaves have been reported to contain some important medicinal components which include rutin [19], antioxidant activity [20], and potential antibacterial properties [21] depending on the extraction method, but other anti-nutritional components released with these compounds such as polyphenols, oxalate and other non-protein amino acids, which consist of 60% free amino acids have been considered as etiology of clinical disorders such as neurodegenerative diseases [1]. Thus, effective detoxification processing is required before consumption to avoid chronic effects and this is of public health concern.

As observed in this study, none of the respondents were aware of any toxic substance in it. Edo State in Southern Nigeria is characterized as a goiter-endemic area [5] and it becomes a public health emergency if the toxicological importance and implications of cassava leaves consumption is not known, since it has been established that it can contribute to the high prevalence of goiter. In similar studies, the mean cyanide content of cassava leaves from the Northern belt of Ghana is higher than other locations and have been reported to be a contributory factor to the high prevalence of goiter and the persistence of iodine deficiency in that geographic region of Ghana [22] and there has also been a correlation between goiter prevalence and cassava consumption in patients of some hospitals in Kilifi county, Kenya [23].

The associations observed ($p=<0.001$) between the experience of illness among respondents due to the toxic effect of improperly processed cassava leaves and socio-demographic characteristics of respondents such as age and occupation may be as a result of ancient cultures or traditions that are associated with the use of cassava leaves, that does not encourage proper processing before consumption.

There is a significant relationship ($p=0.031$) between the ill-health experience of respondents and awareness of high protein content in cassava leaves, which could be traced to the fact that all the respondents were not aware of the potentially toxic substance associated with cassava leaves, including the health implications of consuming improperly processed cassava soup. Furthermore, the

cassava leaf cultivars sampled in the study area exceeded the safety limits [1,24,25], suggesting that cassava leaf cultivars in this location are not safe for consumption, especially when not processed with extensive and reliable methods. The cyanide contents of cassava leaves depend largely on cultivars, high atmospheric temperature, environmental /climatic condition of the location [1]. Most importantly, the cyanide content of the cassava leaves observed in the study area was relatively high to generate health concern.

## CONCLUSION

The study determined cyanide levels, assessed consumption pattern and use of cassava leaves as food and medicinal herbs in goiter endemic communities in Southern Nigeria. There was an overall acceptability of cassava leaves as food, food supplements and herbal therapy among the studied population. The level of illiteracy, lack of awareness about the toxic effect of improperly processed cassava leaves exposed the consumers to the associated health risks after consumption. In the selected communities, the cassava leaves grown had high cyanide levels and exceeded the WHO safety limit, indicating the potential risk of consuming the leave as food or medicinal herbs. The most vulnerable groups in the communities are particularly at risk of cyanide poisoning, especially the children. Proper food safety education is therefore highly advocated in the communities for improved public health status.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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