Journal of Intercultural Ethnopharmacology
www.jicep.com
DOI: 10.5455/jice.20170606094119

Original Research

Ethnopharmacological values of cassava and its potential for diabetes and dyslipidemia management: Knowledge survey and critical review of report

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Received: April 03, 2017
Accepted: May 14, 2017
Published: June 09, 2017

ABSTRACT

Background: Beyond nutritional values are the pharmacological potentials of cassava comparative with other staple carbohydrate plant-based foods such as wheat. The knowledge of applicability to diabetes and its cardiovascular complications management seems not just limited but unacknowledged. As a preliminary study, a community's knowledge of pharmacological value of cassava is investigated. **Methods:** Descriptive observational study using questionnaire-based "cross-sectional" survey was conducted. 136 Participants completed the survey and 101 respondents were selected for evaluation. Open-ended questions were used qualitatively to generate experience and view cassava values for diabetes and dyslipidemia. While categorical (yes or no) questions were used quantitatively to generate numerical results for diabetes, critical reanalysis of a report data was performed, especially comparing carbohydrate/fiber and fat/fiber ratios of cassava with wheat in view of dyslipidemia. **Result:** On the positive side, 42% of the participants believe that cassava has medicinal values. This includes 6% (among the 42) who believes that the plant is useful in treating diabetes and 24% who do not know it may be useful in diabetes management. Critical review showed that cassava may contribute up to sixteen times more fiber and four times less digestible sugar, as well as carbohydrate/fiber and fat/fiber ratios being 14 and 55 times less than wheat. **Conclusion:** There is evidence that relative to wheat flour meal, for instance, cassava contributes less fat and much more fiber. Since fat is pro-obesity, which in turn is pro-diabetic/metabolic syndrome; and fiber is anti-dyslipidemic; cassava has pharmacological values to be appreciated over some carbohydrate plant-based foods.

KEY WORDS: Cassava, diabetes, dyslipidemia, ethnopharmacology, medical nutrition therapy, value chain

INTRODUCTION

Cassava is a farm crop of high nutritive value and known to contain alkaloid among other phytochemicals. Plant alkaloids may be bitter or poisonous, but the high sensitivity of the tongue to bitterness may be a protective mechanism against the poison [1]. At present, diabetes and dyslipidemia are mostly treated with drug therapy. However, limitation of action, safety and high-cost concerns regarding the use of pharmaceutical agents are driving the search for non-pharmaceutical therapies [2,3]. It is known that plant alkaloids have medicinal values for the management of diseases such as diabetes and dyslipidemia [4-6].

Cassava has been known to contain alkaloids [7,8], as well as possessing cyanogenic and flavonoid glycosides [9]. It is also known that flavonoids have antioxidant and hypolipidemic effects [10-12], while glycosides are potent for heart disease [13]. Yet, cassava is rarely talked about for its potential in dyslipidemia or cardiovascular management. For instance, a study of Nigerian flora for hypolipidemic potential never included cassava [14]. While it is acknowledged that "cyanogenic" content portends toxicity, processing such as fermentation is a way of degrading this toxic component as applicable to other plant's cyanogenic glycosides [15]. This is already a conventional practice with cassava [16,17]. Therefore, knowledge of the toxicity may not be a reason for the medicinal values of cassava being rarely talked about.

Absence of Pharmacological Data

Arguably, chief among staple food crops, worldwide, is cassava [18,19]. However, several studies put emphasis on its toxicity [20,21], which seems to overshadow the medicinal values. Many studies reflect on the glycemic index [22-26], without recourse to the impact of processing [27]. This overshadows the potential that cassava can lower cholesterol level in diabetes patients who may be at risk of metabolic syndrome [28]. Yet, it is known that cassava contains alkaloids and flavonoid glycosides with medicinal values [7,9], as well as fiber [24], which can be translated for medical nutrition therapy management of diabetes and its cardiovascular complications including heart disease [10]. These anti- and pro-diabetes potential translations can easily be demonstrated as exemplified in the flow format, viz:

- Cassava > calories and glycemic index > risk of obesity and diabetes > metabolic syndrome
- Cassava > antioxidant flavonoids and fiber > anti-inflammatory and hypolipidemic effects, respectively > metabolic syndrome management.

Despite the above construct being known ideas, there is dearth of data or discussion to substantiate that cassava has pharmacological values for the management of diabetes and dyslipidemia. For instance, a search on PubMed engine with the terms flavonoids and dyslipidemia yielded 504 articles. This substantiates the medicinal value of flavones in dyslipidemia. Addition of the alternative terms cassava or *Manihot esculenta* led to "no items found." Other alternative combinations of the terms "flavonoids//cassava" and "flavonoids//*M. esculenta*" yielded 54 and 48 articles, respectively. These latter figures further substantiate knowledge of flavonoid contents of cassava. In our summation, this is an apparent gap in the literature or lack of theoretical background, and if filled, has the potential to increase the value chain of the plant.

Focus on Cassava for Diabetes and Dyslipidemia – Brief Substantiation

It is probably important to expatiate the furor that diabetic patients are being advised to abandon cassava [29], which has been speculated to either cause or exacerbate diabetes [30-32], despite opinions that cassava is highly unlikely to cause diabetes [31-33]. There is plausible report on flour-based meals in Nigeria that need to be included in international tables of glycemic index. For instance, there is report that presents comparative fat, fiber and glycemic values of cassava relative to wheat [24], but a critical discussion of how the different meals may contribute to dyslipidemia has yet to be.

The molecular mechanism of antidiabetic potential of dietary flavonoids has been reviewed to include improvements in glycolysis, mitochondrial functions, and insulin sensitivity, as well as reductions in gluconeogenesis and oxidative stress among others [34]. Mechanisms of antilipidemic effect of fiber have been identified to include inhibition of bile reabsorption from the stomach by soluble fibers, which in a positive feedback response format enhances the hepatic uptake of cholesterols for more bile productions [35].

Cassava's phytochemicals are comparable to its alternative plant-based carbohydrate food sources such as wheat [8]. With the ongoing prediabetes and cardiovascular complications study (PACCS) programme, and given the lack of pharmacological data vis-à-vis medical nutritional therapy value of cassava in diabetes and dyslipidemia; this project intends to evaluate the level of ethnopharmacological knowledge of the population as well as critically review a report that compares fat and fiber content. This is specifically with a view to generate baseline data on behavioral and value change wheel to design further studies.

MATERIALS AND METHODS

Study Design and Setting

This was a cross-sectional research that followed a questionnaire-based survey and quite similar to the methods of reference reports [36,37]. Instead of using focus groups given its limitations [38], participants were variously stratified on the bases of various socioeconomic characteristics. That is, for the purpose of capturing as many views instead of a common core [39], stratified groups were preferred to "focus groups" after considerations of problems associated with such approach – e.g. it was determined that sampling of 'traditional medicine healers" was inappropriate to represent the population under study, especially because such practitioners are quite scarce and insufficient to constitute sizeable participants within the timeframe of this preliminary data collection. Thus, the setting was clinical research primary location site being the Catholic Hospital Abbi.

Ethical Considerations

The study was set at the instance of a public health screening for PACCS [40], which has been ongoing in Ndokwa-West local government area communities of Nigeria. This was carried out at Catholic Hospital, Abbi, and coordinated by the Global Medical Research and Development Organization in Collaboration with Novena University. Ethics approvals were obtained first from Ndokwa West Local Government Health Department in 2013. Further approvals were obtained from Novena University Nigeria and Charles Sturt University Australia.

Geographical Location and Population of Study

This study was headquartered at Abbi, one of the major rural towns of Ndokwa-West local government area in Delta state of Nigeria. The town is about 100 km from the state capital, Asaba; and approximately, 30 km from the nearest General Hospital, which is located at the local government headquarters in Kwale. The >18-year-old people of Abbi and Ndokwa-West, in general, are predominantly farmers or self-employed craftsmen/women; while a very small fraction are civil servants and much smaller fractions are private company workers and retirees. In the community, traditional medicine practitioners are scarce and the practice is neither lucrative enough to sustain the livelihood of a practitioner

nor practiced as a trade by known graduate scientists. Although the farmers are describable as subsistent, the two most common crops cultivated for both consumption and sales are cassava and pepper. Other two crops produced a little less are maize and yam.

Participants

Participants in this study were from the catchment zone of the Catholic Hospital Abbi – i.e., including neighboring communities and up to local government headquarter. All persons who attended the screening in the period of December 2015-January 2016 were invited to volunteer to complete the questionnaire. Only those who consented were recruited. For the purpose of this evaluation, only those who responded (yes) or (no) to the "Do you think cassava has any medicinal value?" question were included in the study. Hence, sample size was N = 101 comprising 42-(yes) and 59-(no).

Questionnaire

Forty questions were structured under five themes that included medicinal value of cassava and socioeconomic characteristics. Other themes (used in another analysis) were cultivation practices, input/output relationship and value chain. For the purpose of this particular evaluation, only some of the questions in selected themes were employed. Socioeconomic information used included age, gender, educational status, and occupation; while medicinal value questions bordered on knowledge, and practice on health use of cassava [Table 1].

Statistical Analyses

Qualitative and quantitative analyses were performed. Open-ended questions were used qualitatively to generate experience and views. Categorical (yes) or (no) questions were analyzed quantitatively, using Data Analysis Took PAK (Microsoft Excel) to generate numerical results. A total of three evaluations were performed as outlined below:

1. Socioeconomic characteristics: All respondents were distributed into gender group as well as into stratified age, educational level, and occupation. Descriptive statistics were generated. Further, numerical values were assigned and multivariate analysis performed to determine if knowledge or opinion of the medicinal value of cassava differs between stratified groups of socioeconomic characteristics (age, gender, education, and occupation).
2. Medicinal value analysis: This was based on categorical (yes) or (no) to the question: Do you think cassava has any medicinal value? Percentage of the study cohort was determined. Actual diseases known to be treatable with cassava were identified from associated opened-ended questions.
3. Applicability to diabetes: Similar to the preceding determination of general medicinal value evaluation, this focused on percentages of the study cohort – whether "cassava is useful in the management of diabetes." Further, open-ended question was used to generate idea regarding the source of knowledge.

Table 1: Questions on medicinal value of cassava selected for analysis

Question	Yes	No	Unsure
Do you think cassava has any medicinal value?			
Has anyone ever told you about the medicinal value of cassava?†			
Is there any illness that the traditional medicine healer in your community uses product from cassava to treat?‡			
Do you think cassava is useful in the management of diabetes?			
Has anyone ever told you that consuming cassava is good in the management of diabetes?*			

†If yes, what is the medicinal value in curing any illness? ‡If yes, please mention the illness; *If yes, please indicate who told you

Critical Review of a Published Literature

"Fasanmade and Anyakudo glycemic indices of selected Nigerian flour meal products in male Type 2 diabetes subjects. Diabetologia Croatica 2007, 36:33-38" was reviewed. As per the title of report, it was focused on glycemic index and not dyslipidemia. However, values indicating comparative fat and fiber contents were contained. In this critical review, data as presented in result were re-analysed with a focus on dyslipidemia. Discretionally, it was first premised on "assuming equal weights of cassava and wheat flour were mixed and eaten." The compositions of cassava and wheat in 100 g edible portions were viewed in a ratio to each other. Based on indicated data of weight of prepared flour that could contain 50 g of digestible carbohydrate [24], and considering commonly consumed average portion size of each flour being 378 g [41]; the comparative proportion of carbohydrate, fat and fiber components were worked out using Excel Analysis ToolPak.

RESULTS

Descriptive Statistics based on Socioeconomic Characteristics

The descriptive statistics of responses to the "Do you think cassava has any medicinal value?" question, according to stratified socioeconomic variables are present in Table 2.

What is the Medicinal Value?

As a cross-sectional evaluation and based on responses to the question: "Do you think cassava has any medicinal value" 42/101 (≈42%) of the study population indicated (yes). From the associated open-ended question, 4/42 cited malaria and poison from scorpion and snake bites as ailments that can be treated. Evaluating the sources of knowledge among the 42-participants who answered (yes) using the question: "Has anyone ever told you about the medicinal value of cassava?" 13/42 indicated they were told. On probing to affirm the ailments known to be treated with cassava using the question: "any illness that the traditional medicine healer in your community uses product from cassava to treat?" 8/42 indicated (yes), out of which 5/8 responses were obtained in the open-ended questions. From

Table 2: Responses to the "do you think cassava has any medicinal value?"

Stratified socioeconomic variables	Yes	No
Gender; (n=101)		
Female	22	38
Male	20	21
Age (years); (n=101)		
<25	10	5
26-35	6	15
36-45	9	11
46-55	7	10
>55	10	18
Educational level; (n=100)		
No formal	10	8
Primary	21	21
Secondary	10	14
Tertiary	1	15
Occupation; (n=68)		
Craftsman	1	0
Civil servant	8	4
Trader	11	10
Student	6	1
Private worker	6	11
Retiree	1	1
Others	2	6

the associated open-ended question, overall 6/42 identified a health condition (malaria, scorpion bite or snake bite) for which cassava's medicinal value is applicable [Figure 1].

MV in Management of Diabetes

On "Do you think cassava is useful in the management of diabetes?" A different set of six participants (6/42) indicated (yes). Out of the six respondents, four were told – two by medical doctors, one by community health worker, and the forth by a traditional medicine healer; while the remaining two did not specify their sources of information/knowledge. 10 (10/42 or ≈24%) who indicated belief that cassava possesses medicinal value responded categorical (no) on usefulness in management of diabetes, while others (22/42) were unsure.

Critical Review Outcome

Result showed that assuming equal amounts were mixed and eaten together, cassava gives less fat and more fiber than wheat in ratios of 21:79% and 94:4%, respectively [Figure 2]. Further critical review does show that maize meal has comparatively contributes much more fat than cassava in a cassava/maize ratio 5:95.

DISCUSSION

Alternative therapeutic use of herbs for patients with metabolic syndrome [42] and the use of natural substances have become more widespread over the past few years. This is driven undoubtedly by the believe that natural substances are readily

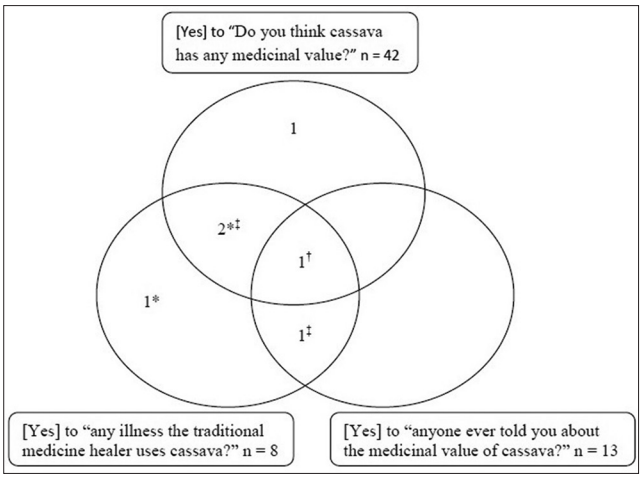

Figure 1: Venn diagram indicating experience and views on medicinal value of cassava. *: Snake bite, ‡: Scorpion bite, †: Malaria

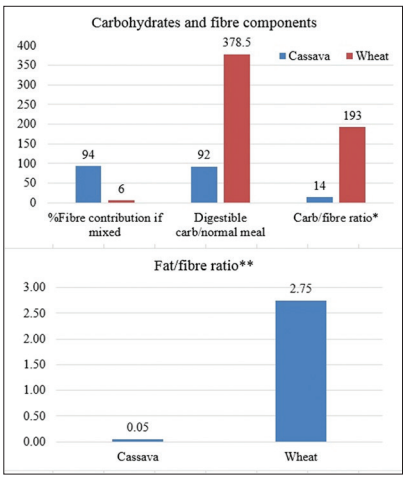

Figure 2: Comparative carbohydrate, fat and fiber contents of cassava versus wheat. *carbohydrate/fiber ratio: ≤10 recommended [48]. Figure indicates that probability level of achieving recommended ratio is relatively hard – i.e., addition of fiber supplement may be necessary, **fat/fiber ratio: Inconsistent inferences of ≤5 [48] and ≤25 [57] implied. Figure indicates that probability level of achieving recommended ratio without supplementation; and five times easier for a ≤25 ratio than ≤5

available to the public and may have fewer side effects than do pharmaceutical [43]. A large number of plant species have been identified as having anti-lipidemia properties and natural products are part of the current therapy for hyperlipidemia [14]. In farming communities like Ndokwa-west local government area in Nigeria where arrays of plants with alkaloids abound, little or none of the plants have yet to be scientifically delineated between "medicines with side-effects" versus poison. Typical among such plants is cassava.

Descriptive statistics indicate that participants with primary or no formal education believe on the medicinal value of cassava, while significantly greater fraction of those with secondary or higher educational level does not accept. Perhaps, this is a factor of trust in traditional medicine healers. However, it does reflect that the more educated persons seem to ignore ethnobotanical medicines, despite the known fact that the leaves of the plants

are made for healing [44]. It is interesting to note that 16% of the participants have tertiary education, out of which only 6% (1/16) of the subpopulation indicated (yes). While 42% (10/24) of participants with secondary education are aware of the potential medicinal value of cassava, 50% of those with primary education; and much higher percentage (10/18 ≈56%) of those with no formal education do. Therefore, it seems generally or hypothetically that the higher the educational status, the less is the belief in ethnobotanical medicine.

Up to 6% of the participants indicated that cassava is useful for the treatment of scorpion and snake bites [Figure 1]. Perhaps, it is pertinent to note that both bites have blood clotting and hemolytic as well as cardiotoxic properties. It is also important to acknowledge that treatment of snake bites with plants has been unquestionable in the science domain, especially if there is evidence of metabolites such as alkaloids, flavonoids, or tannins [45,46]. Therefore, identification of cassava, which has alkaloids, flavonoid glycosides and tannins among others [7,9], being used to treat scorpion or snake bite in this community and reportedly used in India and Papua New Guinea is in tandem intercultural ethnopharmacology. However, to our knowledge and as indicated in our results, it has been scarcely known that medicinal value of cassava includes anti-venom properties.

Another 6% of the study population is aware that cassava has value in diabetes management, and half of these respondents got informed by conventional health-care officers. This implies knowledge of the ethnomedicinal value of cassava for diabetes management among Western health-care professionals, which translates to capacity to motivate public awareness.

Perhaps, what should be worrisome is the seemingly absolute lack of knowledge that cassava has hypolipidemic properties. This concern is given the knowledge that low fat/fiber foods are preferable for diabetes and CVD management [47,48]. The response to qualitative questions yielded no indication of knowledge dyslipidemic values. We have noted from literature review that a study of Nigerian flora for hypolipidemic potential never included cassava [14]. Hence, it is probable (and hereby hypothesized) that the limit of ethnomedicinal knowledge of plants in communities may be due to the limitations of scope or target of researchers. Scope: In the sense that discussions/studies on cassava usage for dyslipidemia are lacking; and target: in the sense that the elites in the community need to be reached with ethnomedicinal research reports. In the context of value chains of ethnomedicinal plants [49,50], consideration of this hypothesis will translate to capacity-building for public awareness campaign on medical nutritional therapy value of the plant in dyslipidemia management.

Interestingly, our critical review of comparative fat and fiber contents of cassava relative wheat flour shows that Assuming equal amounts were mixed and eaten together; wheat will contribute more absorbable fat and much less antidyslipidemic fiber than cassava [Figure 2]. It is known that dietary fiber is capable of reducing the risk of metabolic syndrome including diabetes and dyslipidemia [51-53]. It is also known that differences in level of fiber nutrients constitute a factor in dietary management of cardiovascular disease [54]. In particular, fat/fiber and/or carbohydrate/fiber ratios are inferable, or recommended, respectively [47,48]. The gap in knowledge, attitude, or research practice is the therapeutic value of cassava for diabetes and dyslipidemia management relative to other flour meals such as wheat.

Indeed, studies on nutritive and phytochemical composition of cassava have reported different medicinal values but made no mention on the use of cassava for diabetes and dyslipidemia management [55]; just as hypolipidemic Nigerian flora without mentioning cassava [14]. It has been said that in diabetes, "cassava could be a healthier choice than wheat and white potatoes [24]," but there is no scientific evidence in the literature on the use of cassava for diabetes and dyslipidemia management. The lack of evidence is the justification for this study vis-à-vis preliminary survey "to develop hypothesis" and it is only a step in long-term research program.

There is no arguing the fact that a high-fiber diet is therapeutic [56]. What this paper is articulating and bringing to the fore is that cassava has a medical nutrition therapeutic value for diabetes and dyslipidemia based on its healthier carbohydrate/fiber and fat/fiber ratios compared to wheat [Figure 2], which will be appreciated by considering the following recommendations of adequate intake:

- Carbohydrate and fat are approximately 55% and 27.5% of calories, respectively [57]. This implies a carbohydrate/fat ratio of 2/1 or ≥2 for dyslipidemia management. That is, for every 10 g of carbohydrate consumed, at most 5 g of fat may be the optimum.
- Carbohydrate/fiber ratio is ≤10, which means for every 10 g of carbohydrate food consumed, at least 1 g of fiber is may be the healthy dietary requirement [48].

Given the recommendations or references, it may be that for every 10 g of carbohydrates edible meal, 5 g of fat and 1 g of fiber is the required adequate intake. Hence, the fat/fiber ratio need to be 5/1 or ≤5. However, recommended adequate intake of fiber is 14 g/1000 kcal [57], which translates to a requirement of 19.6 g fiber/day on a 1800 calorie daily diet that may contain (27.5 % of 1800) 495 g fat. This is 495/19.6 or ≤25 fat/fiber ratio; inconsistent with 1 g fiber/5 g fats or 10 g carbohydrate inferred from the recommendation of Atkins *et al*. Nevertheless, considering the fact that average portion size of each flour consumed separately is 378 g [41], our critical review showed that:

- On the positive or healthy side: Cassava may contribute 16 times more fiber and four times less digestible sugar;
- On the negative or unhealthy side: Wheat has carbohydrate/fiber and fat/fiber ratios that are 14 and 55 times greater than cassava [Figure 2].

With increasing knowledge and processing advancement, the nutritive benefit of cassava is inexhaustible. One will expect that with the high content of starch in cassava root and the many consumable end products, as well as the very fact that these products have been and remain the main staple food in southern Nigeria; there are several chemical agents in cassava that will

protect against diabetes and dyslipidemia/obesity. Without these occult agents, there would have been higher incidences of these conditions in the various or intercultural communities where cassava is a staple carbohydrate food. Further studies will be encouraged in other to provide biochemical data to support these lines of thought. Further, the proposal following this hypothesis is to community (of researchers and elites) needs assessment and behavioral change wheel. This recent paper provides a start point in this direction.

Limitations

This study has a very narrow focus, which is the therapeutic value of cassava for diabetes and dyslipidemia. It does substantiate that there is a lack of clinical data in this regard, but the lack of data also means that theoretical background is limited. Nevertheless, the reported observations do provide an indication of intercultural ethnopharmacological and nutritional usage of cassava, as well as highlights of undiscussed evidence on the value of cassava for dyslipidemia.

CONCLUSION

This study affirms that beside the dietary benefits of cassava as a staple food and it has therapeutic values that are being adopted in intercultural ethnomedicine. However, the hypolipidemic potential is yet unknown and the relatively higher fiber content is still to be put into perspective. Evidence of the knowledge of possible use to lower hyperlipidemia and regulate diabetes complications need to be investigated and translated into value chain potentials to maximize its health and overall economic benefits.

ACKNOWLEDGMENT

The Catholic hospital Abbi is collaborating in the PACCS work is hereby acknowledged. Staff and students of Public and Community health department of Novena University have also supported this work during data collection. Prominent among them is Dr. Kester Digban.

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Source of Support: Nil, Conflict of Interest: None declared.