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Qualitative and Quantitative Analyses of Phytochemicals in Commonly Consumed Traditional Carbohydrate-based Dishes in Enugu State, Nigeria

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Abstract

Qualitative and quantitative analyses of phytochemicals in some traditional dishes commonly consumed in rural and urban communities in Enugu State were carried out in this study. Laboratory analysis and cross-sectional survey designs were adopted in the study. The dishes were documented using Focus Group Discussion (FGD) in each selected community. Ingredients used in preparing the dishes were purchased from the communities' major markets. The dishes were prepared, homogenized, and screened for Alkaloid, Saponin, Terpenoid, Steroid, Glycoside, Flavonoid, Tannin, Phenol, and Carotenoid. Subsequently, Alkaloid, Phytate, Oxalate, Saponin, Tannin, and Phenol present in the samples were quantified using standard procedures. Statistical Package for Service Solution (SPSS) version 22 was used to analyze the data obtained. The FGD result revealed ten ("akpu" with cocoyam, pounded white yam, boiled white yam, "akpu" with pounded white yam, "akpu" with pounded water yam, "akpu" with "garri", garri, boiled rice, "elubo" and "akpu") commonly consumed carbohydrates-based dishes. The screening result showed that alkaloid was present in appreciable amount in white pounded yam (+++) but was not detected in "akpu" with pounded "garri". Terpenoid, steroid, glycoside, flavonoid and carotenoids were not detected in all the samples. The phytochemical composition of the traditional carbohydrate-based dishes in percentages (%) were 0.27-3.22 for alkaloid, 0.01-0.11 for phytate, 0.02-0.21 for oxalate, 2.08-13.04 for saponin, 0.06-0.55 for tannin and 0.07-0.88 for phenol. "Elubo" had the highest Alkaloid and Oxalate concentration (3.27±0.03 and 0.21±0.23 respectively). "Akpu" with pounded cocoyam had the highest Saponin and Tannin concentration (13.04±0.03 and 0.55±0.00 respectively) while boiled rice had the highest Phytate and Phenol composition (0.11±0.13 and 0.88±0.00 respectively). Many phytochemicals (Terpenoid, steroid, glycoside, flavonoid and carotenoid) were not detected in any of the ten documented dishes while all of them except "akpu" and pounded garri, contain appreciable amount of alkaloids and phenols.

Keywords: Phytochemicals, Traditional dishes, Focused group discussion, Ingredients, Food consumption

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Introduction

Traditional foods are defined as food native to a particular region or present in that region long enough to have evolved through natural processes or farmer selection (Jansen et al., 2007). Traditional foods are consumed in a locality by many generations. They are foods consumed throughout history before the modernization and industrialization of the food supply (Katie, 2019). According to Ayogu et al. (2017), commonly consumed foods in an area are those foods that have high consumption frequencies of more than three times per week. Population groups of any area always depend on such foods and most often these foods are of traditional origin and are therefore made into traditional dishes.

A dish is defined as a ready-to-eat food that can be consumed on its own without accompaniment (Ayogu et al., 2017). Hence, traditional dishes are referred to as ready-to-eat foods prepared from local foodstuff and made into local dishes for consumption (Olojede, 2010). Many traditional commonly consumed dishes in Nigeria are carbohydrate-dense and are often referred to as starchy staples. These traditional dishes are associated with a particular ethnic group, locality, community, or society (Amadi et al., 2018), are characteristic of the cultural heritage of the people, and have evolved to form key elements in the dietary pattern of the people. In a multi-cultural society like Nigeria, different traditional dishes abound which are indigenous to different ethnic groups and tribes (Olayemi & Rahman, 2013).

Traditional foods are natural and fresh. They are valued because they showcase the culinary tradition of the people and have a lot of benefits for health (Agomuo et al., 2017). Traditional foods are mostly associated with health benefits as identified by their categories; green leafy vegetables, roots and tubers, fruit, and legumes (Majova, 2011). This is because most of the plant-based dishes contain some healthful compounds known as phytochemicals attributable to their being prepared in their natural forms without much processing (Majova, 2011).

Naturally occurring compounds, known as phytochemicals, are thought to be largely responsible for the protective health benefits of plant-based foods and beverages, beyond those conferred by their vitamin and mineral contents. They are naturally occurring, biologically active chemical compounds found in plants (Kumari & Khatkar, 2012). These phytochemicals, which are part of a large and varied group of chemical compounds, also are responsible for the color, flavor, and odor of plant foods, such as blueberries' dark hue, broccoli's bitter taste, and garlic's pungent odor. The benefits of phytochemicals such as flavonoids, phytates, tannins, oxalates and carotenoids include reducing the risk of chronic diseases by protecting against free radical damage, modifying metabolic activation and detoxification of carcinogens, or even influencing processes that alter the course of tumor cells (Herrera et al., 2009).

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Traditional diets, which are rich in carbohydrates, protein, vitamins, minerals, dietary fibre, and phytochemicals, are being neglected and preference is being given to highly processed fat and sugar-rich foods that are low in fibre and phytochemicals. Highly processed foods predispose consumers to overweight and obesity which are considered risk factors for many chronic non-communicable diseases (NCDs). The Nigerian population is becoming more overweight and obese as shown by recent data from WHO Noncommunicable Diseases Country Profile, 2010 (Maiyaki & Garbati, 2010). Overweight and obesity may increase the risk of many health problems, including type 2 diabetes, high blood pressure, heart diseases, strokes, certain types of cancer, sleep apnea, osteoarthritis, fatty liver disease, kidney disease, and pregnancy problems, such as high blood sugar during pregnancy, high blood pressure, and increased risk for cesarean delivery, (National Institute of Diabetes, Digestive and Kidney Diseases (NIDDKD), 2015). Although these changes affect both rural and urban dwellers, they are more pronounced among the urban populace. These changes are brought about by changes in dietary habits, with the adoption of a Westernized diet. The facilitation of social acceptance of fast food by global media outlets and advert billboards has potentiated this nutritional transition (Maiyaki & Garbati, 2010).

Traditional foods are being displaced in many areas, partly because they are being neglected by the science community, in comparison to some recently introduced Western foods, which are more easily available (Majova, 2011). In some developing countries like Nigeria, some indigenous foods are less consumed despite the potential health benefits due to their natural and non-toxic or non-chemical nature. There is a paucity of empirical data on the phytochemical composition of traditional dishes. This lack of information might be a reason for the reduced consumption of traditional dishes. This study, therefore, aimed at documenting and analysing (qualitatively and quantitatively) the phytochemical in traditional dishes commonly consumed by rural and urban dwellers in Enugu State, to provide evidence-based information that can be used by nutrition educators to promote healthy consumption patterns among urban and rural dwellers in South-eastern Nigeria. This vital information on the phytochemical composition of traditional dishes is also needed for the development of country-specific food composition databases which is an indispensable working tool for nutritionists in the country for use in dietary counselling.

Objectives of the study. The objectives of the study were to;

1. document the traditional carbohydrate-based dishes commonly consumed in Enugu State;
2. determine the phytochemicals (Alkaloid, Saponin, Terpenoid, Steroid, Glycoside, Flavonoid, Tannin, Phenol and Carotenoid) that were present (quantitative analysis) in the food samples and

3. determine the concentration (quantitative analysis) of phytochemicals (Alkaloid, Phytate, Oxalate, Saponin, Tannin and Phenol) in the food samples.

Materials and methods

Area of the study: Enugu State is one of the thirty-six States in the Nigerian Federation. Enugu State is one of the Igbo-speaking states in Nigeria. The state is divided into three senatorial zones namely: Enugu North, Enugu East, and Enugu West. Enugu North and East senatorial zones are made up of six Local government areas each while Enugu West is made up of five Local Government Areas. Agriculture plays an important role in the state's economy. Yam, palm oil products, cocoyam, maize rice, and cassava are the main crops and therefore constitute major foods of the residents of Enugu State.

Study design: This study adopted laboratory analysis and cross-sectional survey designs to achieve its objectives. The laboratory analysis involved the qualitative and quantitative determination of phytochemicals in traditional dishes commonly consumed in Enugu State. This approach is essential in understanding the biochemical composition and health implications of these foods (Nkansah et al., 2020). Laboratory analysis provides precise data on the phytochemical content, which is critical for validating nutritional claims and identifying bioactive compounds (Ogundele & Adewumi, 2019).

The cross-sectional survey design was employed to gather data on the commonly consumed traditional dishes among the local population. This design is particularly relevant for studies seeking to capture a snapshot of behaviors and preferences within a defined period (Creswell & Creswell, 2018). By combining these methods, the study bridges the gap between laboratory findings and real-world dietary practices, offering a holistic view of the phytochemical intake from these dishes.

Selection of Focus Group Discussants: Out of the three senatorial zones (Enugu North, Enugu East, and Enugu West) that make up Enugu State, Enugu North, and Enugu East were purposefully selected for the study. One Local Government Area was also purposefully selected from each of the two selected senatorial zones (Enugu North and Enugu East). Two communities (urban and rural) were also purposefully selected from each of the selected LGAs making a total of four communities. The purposeful selection was based on familiarity with the researchers. Eight women participants were selected for the focus group discussion (FGD) in each of the four communities making a total of thirty-two women.

Preliminary visit: An introductory letter was presented to the Local Government Chairman of each selected LGA with whom an appointment had earlier been booked. The researchers obtained permission from the chairmen to carry out the study in their LGAs. The Local Government Chairman connected the researchers to some members of the communities who became the research assistants. The researcher enlightened the research assistants on the aim and the expected results of the study and solicited the support, cooperation, and consent of participants. The research assistant gathered women who participated in the focus group discussion.

Instrument for Data Collection: A focus group discussion (FGD) protocol was used to obtain data on the commonly consumed traditional dishes in the four communities. The FGD provided all necessary information on the traditional dishes in each of the communities which included the names of the dishes, ingredients list, and methods of preparation. Each session lasted for 45-60 minutes. A researcher moderated all focus discussions while the others assisted. One of them took notes on the discussion the second person operated the tape recorder which was used to record the focus group discussion to obtain a verbatim report while the third researcher took pictures of the process.

Procurement of ingredients: All the ingredients used in the preparation of the documented carbohydrate-based dishes were purchased from the major market of the community where the dishes were documented.

Food sample preparation: All the traditional dishes documented in each community were prepared by women from those communities using the recipes collected from the FGD. The women were transported to the laboratory where the food preparation was carried out. The food preparation was done in the Food and Nutrition Laboratory, Department of Home Science and Management, University of Nigeria Nsukka. After preparation, the food samples were homogenized, properly labelled, and taken to the Food Analytic Laboratory, Department of Home Science and Management, University of Nigeria Nsukka for qualita tive and quantitative evaluation of phytochemical.

Recipe of akpu and pounded white yam

Ingredients	**quantity**
Raw akpu paste	1000g
Peeled raw yam	500g

Method of preparation

- Homogenize the raw akpu paste and form into big balls.
- Add the balls into a pot of boiling water and boil for fifteen minutes.
- Remove from the pot and pound.
- Form the partially cooked akpu into balls again and boil for another fifteen minutes.
- Pound very well, adding a small quantity of water at intervals to achieve the desired consistency and set aside.
- Boil the yam till tender
- Pound very well, add the pounded akpu and pound again until both are totally blended.

This method of preparation is applicable to akpu and pounded water yam, akpu and pounded cocoyam and akpu and garri except that cocoyam is peeled after boiling while garri is not boiled but added into a bowl of right quantity of very hot water and stirred very well before adding to the pounded akpu. For elubo, cassava flour is gradually added into boiling water and stirred like semovita.

Chemical analysis
Quantitative and qualitative evaluation of phytochemicals of all the samples were done in duplicate and presented on a wet weight basis.

Phytochemical screening: Mayer's test described by Ajuru et al. (2017) was used to determine the presence of an alkaloid. The test recommended by Trease and Evans (2002) was used to detect the presence of terpenoids. Water was added to the test solution, and the mixture was shaken thoroughly. The formation of copious lather indicated the presence of saponins. Copious lather formation after shaking the test solution in water indicated the presence of saponin. Ajiboye et al. (2013) method was used to test for carotenoids. For tannin, the test solution was mixed with basic lead acetate solution. The formation of a white precipitate indicated the presence of tannin. For the glycosides test, the extract was boiled with dilute sulphuric acid, and chloroform was added and shaken well. The organic layer was separated into which ammonia was added slowly. The presence of glycoside was denoted by pink to red colour. Magnesium solution and a few drops of concentration hydrochloride acid were added to 2ml of the test solution and boiled for 5 minutes. The appearance of red or orange colour indicates the presence of flavonoid. To 2ml of the test solution, a few drops of ferric chloride solution were added. A bluish green colour indicates the presence of phenol. A few drops of chloroform, 3-4 drops of acetic anhydride, and one drop of concentrate sulphuric acid were added to 2ml of the test solution. The appearance of purple colour, which changes to blue or green colour, showed the presence of steroids.

Quantitative analysis of phytochemicals
Alkaloid content was determined by the alkaline precipitation-gravimetric method described by Harborne (1973). Total oxalate in the sample was assayed using the method of AOAC (1995) while AOAC, (2010) was used for tannin and phytate determination. Saponin was determined according to the Ochuko and Obadni method (2001). Boham and Kocipia-Abyazan method (1994) was used for flavonoids determination. Method of analysis of Analytical Methods Committee of Royal Society of Chemistry, (A.M.C.R.S C) was used for phenols determination.

Statistical analysis: Data obtained from chemical analysis were analyzed statistically using Statistical Product for Service Solution (SPSS), version 22, and presented as Mean ± Standard deviations.

Results

Documentation of the dishes
The FGD results revealed that there was a total of ten traditional carbohydrate-based dishes that are commonly consumed in Enugu State. The ten documented dishes include akpu with pounded cocoyam, pounded white yam, boiled white yam, akpu with pounded white yam, akpu with pounded water yam, akpu with pounded garri, pounded garri, boiled rice, elubo, and pounded akpu.

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Table 1. Documented traditional dishes

Samples	Components	Ratio%
APC	Akpu (fermented cassava paste) with pounded cocoyam	50:50
WYP	Pounded white yam	100
AYP	Akpu with pounded white yam	50:50
WYB	Boiled white yam	100
AWP	Akpu with pounded water yam	50:50
AGP	Akpu with pounded garri (fried cassava grits)	50:50
GRP	Pounded garri	100
BRC	Boiled rice	100
EBO	Elubo (cassava flour meal)	100
APO	Pounded akpu	100

Table 2 represents the phytochemical screening of carbohydrate-based dishes. Alkaloid was present in appreciable amounts in pounded white yam (+++) but was not detected in akpu with pounded garri. Saponin, tannin, and alkaloid were present in moderate amounts (++) in boiled white yam (WYB), akpu with pounded white yam (AYP), and akpu with pounded water yam (AWP) respectively. All the samples contained phenol in a minimal amount (+). Terpenoid, steroid, glycoside, flavonoid, and carotenoid were not detected in all the dish samples.

Table 2. Qualitative analysis of phytochemical content of the traditional carbohydrate-based dishes

	Alkaloid	Saponin	Terpenoid	Steroid	Glycoside	Flavonoid	Tannin	Phenol	Carotenoid
APC	+	+	–	–	–	–	+	+	–
WYP	+++	+	–	–	–	–	–	+	–
WYB	++	++	–	–	–	–	–	+	–
AYP	+	–	–	–	–	–	++	+	–
AWP	++	–	–	–	–	–	+	+	–
AGP	–	–	–	–	–	–	–	+	–
GRP	+	–	–	–	–	–	–	+	–
BRC	++	+	–	–	–	–	–	+	–
EBO	+	–	–	–	–	–	–	+	–
APO	+	–	–	–	–	–	++	+	–

Key: Present in appreciable amount +++, moderately present ++, mildly present +, absent - . APC= Akpu with pounded Cocoyam,WYP= Pounded white yam,WYB= Boiled white yam,AYP= Akpu with pounded white yam,AWP= Akpu with pounded water yam, AGP= Akpu with pounded garri,GRP= Pounded garri,BRC= Boiled rice,EBO= Elubo,APO= Pounded Akpu

Table 3 presents the phytochemical compositions of the traditional single ingredient dishes. Elubo (EBO) had the highest concentration of alkaloid (3.27%), followed by Akpu with pounded cocoyam (3.22%) and boiled rice (3.12%). Akpu with pounded yam (APC) had the highest saponin concentration (13.04%), while boiled white yam had the least (2.08%). Akpu with pounded yam (APC) had the highest tannin concentration (0.55%). The alkaloid content of the carbohydrate-based dishes ranged from 0.27-3.27% while Phenol values were within the range of 0.17-0.88%.

Table 3. Phytochemical Compositions of the Traditional Dishes

Sample	Alkaloids (%) mean±SD	Phytate(%) (mean±SD)	Oxalate(%) (mean±SD)	Saponin(%) (mean±SD)	Tannin(%) (mean±SD)	Phenol(%) (mean±SD)
APC	3.22±0.05	0.01±0.00	0.08±0.01	13.04±0.03	0.55±0.00	0.20±0.00
WYP	0.84±0.01	0.01±0.00	0.02±0.00	3.06±0.08	ND	0.17±0.01
WYB	0.27±0.01	0.01±0.00	0.02±0.00	2.08±0.02	ND	0.21±0.01
AYP	0.88±0.28	0.02±0.00	0.10±0.02	ND	0.10±0.00	0.19±0.00
AWP	1.01±0.01	0.03±0.00	0.02±0.00	ND	0.06±0.00	0.39±0.01
AGP	ND	0.02±0.00	0.07±0.02	ND	ND	0.24±0.02
GRP	0.91±0.14	0.02±0.00	0.02±0.00	ND	ND	0.32±0.01
BRC	3.12^{h}±0.01	0.05±0.00	0.02±0.00	2.84±0.07	ND	0.34±0.00
EBO	3.27±0.03	0.02±0.00	0.21±0.23	ND	0.06±0.00	0.07±0.01
APO	0.39±0.00	0.04±0.00	0.10±0.01	ND	0.44±0.01	0.14±0.00

KEY: ND= Not detected, APC= Akpu with pounded Cocoyam, WYP= Pounded white yam, WYB= Boiled white yam, AYP= Akpu with pounded white yam, AWP=Akpu with pounded water yam, AGP=Akpu with pounded garri, GRP= Pounded Garri, BRC= Boiled rice, EBO= Elubo, APO= Akpu.

Discussion

Documentation of traditional carbohydrate-based dishes

The study aims to identify the phytochemical composition of traditional dishes commonly consumed in Enugu State. As many as ten carbohydrate-based (yam, cassava, rice, and cocoyam) dishes were documented confirming the fact that starchy staples are commonly consumed in Enugu State. This is in line with existing literature. Ene-Obong et al. (2013) observed that yam and cassava and their products were consumed almost daily by over 70% of the respondents in southern Nigeria. According to Davidson et al. (2017), it has been established that a high percentage of the population in southeast Nigeria depends almost solely on starchy staples like cassava, rice, and yam. The high consumption rate of starchy staples is well expected since farming is a major occupation in Enugu state, and cassava, yam rice, and cocoyam farming are the major agricultural activities in the area. The result obtained by Nimenibo and Oriakhi, (2017), on raw trifoliate/bitter yam from Agenebode farm in Edo State,

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is slightly different from the phytochemical screening results obtained from pounded and boiled white yam in this study because the authors observed the presence of flavonoid, alkaloid and saponin in minimal amount (+) and absence of tannin. The difference could be due to location and the variety of the yam. Phytochemical compositions of plants are mostly found to differ both qualitatively and quantitatively depending on exposure to stimuli, geographical location, and soil type (Sechene, 2018). Khattak et al. (2015) in their study, stated that geographical distributions affect the levels of phytochemicals and their biological activities.

This study also revealed that alkaloids were present in moderate amounts (++) in boiled rice, saponin and phenol were present in minimal amounts (+), while tannin, terpenoid, steroid, glycoside, flavonoid, and carotenoid were not detected. This is similar to the reports of Moko et al. (2014) that flavonoids and alkaloids are moderately (++) present in rice bran, and phenol, triterpenoid, and saponin compounds are present in a minimal amount (+). Phytochemicals are distributed in free, soluble-conjugated, and bound forms in the endosperm, bran/embryo fractions of the whole rice grain (Ali et al., 2018). Islamiyat et al. (2016), in their study, reported that cooking reduces glycosides, and this could be the reason why glycoside was not detected.

The result of this study showed that alkaloid, tannin, and phenol are present in minimal amounts (+) in pounded "akpu", while saponin, terpenoid, steroid, glycosides, flavonoid, and carotenoid were not detected. This is slightly different from the reports of Ebuehi et al. (2005) on raw cassava tuber which contained alkaloids (++) in moderate amounts, flavonoids, and tannins in minimal amounts (+), while glycosides and saponins were not detected. This could be a result of the processing and variety of the plant. The phytochemical content of cassava depends on the specific plant part (root or leaves), variety, age of the plant, and environmental conditions (Ezeocha & Ojimelukwe, 2012).

Quantitative composition of the selected traditional dishes

It was revealed in this study that "akpu" with pounded cocoyam contains tannin (0.55%) and phytate (0.01%). The result of this study disagrees with that reported by Adejoro et al., (2013) who showed that boiled cocoyam contains tannin (0.18%) and phytate (0.40%). This could be attributed to the quantity of water used in boiling and the extent of boiling. Soaking in water, cooking to dryness, and roasting in the fire can be used to reduce the phytate, tannin and oxalate content of cocoyam (Ndimantang et al., 2006). Processing methods such as soaking, boiling and fermentation lowers the tannin and phytate content of foods (Ezeocha & Ojimelukwe, 2012). The decrease in the tannin levels during cooking may be due to the thermal

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degradation and denaturation of the tannin as well as formation of insoluble complexes (Ezeocha & Ojimelukwe, 2012). Reduction in tannin content observed by Adejoro et al. (2013) might also be attributed to the fact that tannins are polyphenols, and all polyphenolic compounds are water soluble. "Akpu" with pounded cocoyam also had a higher oxalate content (0.08%) when compared to the study of Bamidele et al. (2015), who reported 0.02% of oxalate in "akpu" and cocoyam (ratio of 4:1). This could be as a result of the species and processing method used. It is documented that oxalate content varies with species and cultivars (Lewu et al. 2010). Processing techniques are used to counteract or denature anti-nutritional factors and increase the nutritional value of food products (Montagnac et al. 2009). Oxalates are soluble in boiling water and are reduced during boiling (Adane et al. 2013). As indicated by Albihn & Savage (2001), boiling may cause considerable skin rupture and facilitate the leakage of soluble oxalates into cooking water. The alkaloid content of "akpu" with pounded cocoyam in this study (3.22%) is similar to the report of Madukosiri & Opara (2015), that dried edible portion of cassava contains 3.34% of alkaloid.

The result of this study also revealed that tannin was not detected in boiled white yam and pounded white yam, and this contradicts that reported by Olajumoke *et al.,* (2014), who showed that tannin content of boiled pounded yam and raw yam is 0.38% and 0.41% respectively. Pounded white yam also, in this study contains phytate (0.01%), oxalate (0.02%), saponin (3.06%), and alkaloid (0.84%). This disagrees with the result of Olajumoke et al. (2014), who showed that boiled pounded yam contains phytate (4.37%), oxalate (0.54%), tannin (0.38%), saponin (12.71%) and alkaloids (2.02%). The disparity in these results could be because of the boiling and variety of the yam used. Processing methods such as soaking, boiling, and fermentation lower the phytochemical content of foods (Ezeocha & Ojimelukwe, 2012). Boiling to dryness, pounding, roasting, parboiling, mashing and sun drying reduces the phytochemical content in yam (Adepoju et al., 2016).

The phytate content of boiled rice was o.05% and this is much lower than the range (<0.25%) reported by Juan et al. (2014), for the phytate content of polished rice. This could be attributed to the fact that local rice which is unprocessed was used in the present study. Various studies have shown that processing methods such as boiling, milling, fermentation, and roasting can significantly reduce phytate and tannin to a low level (Wada et al. 2019). Milling and polishing reduce the phytochemical properties of different rice varieties (USDA, 2013). Separation of bran/husk reduces the nutrient content and phytochemical composition but improves digestibility and/or bio-accessibility (Oghbaei et al., 2016). Phytic acid content may also vary depending on the crop variety, climatic conditions, irrigation conditions, soil type, and growing season of the plant (Lewu et al., 2010). The result of this study also revealed that boiled rice had a high content of phenol (0.88%), and this contradicts the reports of Oselebe et al. (2013), who revealed that uncooked rice contains 0.74% of phenol. The low content of phenol in the reports of Oselebe et al., (2013), could be attributed to the cultivar used and the degree of processing. Piebiep and Henrique (2014) in their study, reported that *japonica* rice varieties possess more phenolic acids and more flavonoids when compared with *indica* rice varieties. This, however, shows that the phenol content of rice could be attributed to the varieties used. In the reports of Keneswary et al. (2018), the phenolic compounds of rice were shown to decrease by increasing the degree of milling. White rice has a lower phytochemical and nutritional value when compared to whole rice grain, due to loss of phenolics and other bioactive compounds through processing (Gong et al., 2017).

"Elubo" (cassava flour meal) in this study had the highest alkaloid content of 3.27%, tannin (0.06%), while no saponin and flavonoid were detected in it. This result contradicts that of Oluwaninyi and Oladino, (2017) which revealed that cassava flour contains alkaloid (11.69%), tannin (0.22%), flavonoid (3.50%) and saponin (2.39%). The differences in the result could be as a result of processing methods such as cooking, varieties, and maturation period of the cassava. Simple processing such as cooking removes the alkaloid and saponin present in most cultivated species of cassava (Adebowale et al., 2018). Boiling, steaming and frying affect the phytochemicals in food (Prasanna et al., 2018). As the degree of milling increases, the loss of phytochemical compounds beneficial to health increases, and cellular antioxidant activity decreases (Keneswary et al., 2018). Oluwaninyi and Oladino, (2017) in their study showed that phytochemicals (oxalate, alkaloid, and flavonoid) increase with maturation. The difference in the contents of bioactive compounds depends on many factors such as the cultivar of the plant, stage of maturity, and soil type (Oszmianski et al, 2018).
In this study, "akpu" with pounded water yam contains phenol (0.39%), alkaloid (1.01%), and tannin (0.06%). This result disagrees with the study of Ezeocha and Ojimelukwe (2012) who reported that raw water yam contains phenol (1.91%), alkaloid (2.77%), and tannin (0.21%). The low phenol, alkaloid, and tannin content observed in the present study could be attributed to cooking. Processing such as soaking, drying, and cooking could degrade the phytochemical contents in food (Hotz & Gibson, 2007).

This study revealed that carotenoid, flavonoid, terpenoid, steroid, and glycosides were not detected in all the traditional dish samples. The study by Carvalho et al. (2017) revealed that raw yellow cassava roots contained 2.64µg/g of carotenoid. Also, Bolarinwa, et al., (2017), revealed that cassava flakes ("garri") contained 0.46µg/g of carotenoid. Reports of Ojo and Akande, (2013) also revealed that "garri" contained glycosides (0.04g/100g). These reports contradict the result of this study which showed that carotenoid and glycoside were not detected in pounded "akpu", "akpu" with pounded "garri", "akpu" with boiled yam, "akpu" with pounded yam, "elubo" and boiled rice. The disparity in these results could be due to cooking, processing methods, and different plant species used. Phytochemicals in food may be degraded by processing techniques, including cooking. Different processing methods contribute to the loss of phytochemicals in food (Ayse & Ebru, 2017). Cooking reduces the amount of glycoside and saponin in food while preparation and processing of food decreases its flavonoid levels (Kumar & Panday, 2013).

Conclusion

This study provided baseline information on the phytochemical compositions of some traditional carbohydrate-based dishes commonly consumed in rural and urban communities in Enugu State. Most of the traditional dishes studied were low in oxalate, phytate, tannin, and phenol. No terpenoid, steroid, glycoside, flavonoid, or carotenoid were detected in all the carbohydrate-based dishes. Three of the carbohydrate-based dishes ("elubo", "akpu with pounded cocoyam, and boiled rice) had a high mean value of alkaloid, but it was not detected in "akpu" with pounded "garri". Traditional carbohydrate-based foods, especially roots and tubers, contain some phytochemicals that have the potential for control and prevention of some health-related diseases if traditional dietary habits are maintained.

Recommendations

Based on the results of the study, the following recommendations were made

1. Carbohydrate-based dishes are devoid of many phytochemicals. Nutrition educators should, therefore, encourage consumers to eat them together with other phytochemical-rich dishes such as soups, stews and sauces to encourage optimum phytochemical intake.
2. Qualitative and quantitative analysis of traditional carbohydrate-based dishes commonly consumed in other communities in Enugu State should be carried out.

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