International Journal of Community Medicine and Public Health
Balogun OO et al. Int J Community Med Public Health. 2024 Jul;11(7):2606-2613
http://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20241813

Original Research Article

Nutrient composition of cassava flour fortified with pumpkin leaves and its effects on post-prandial blood glucose level among diabetes patients

Olanike O. Balogun[1]*, Olajumoke P. Olaniran[1], Motunrayo T. Oduneye[2]

[1]Department of Human Nutrition and Dietetics, Lead City University, Ibadan, Nigeria
[2]Dietetics Department, University College, Teaching Hospital, UCH Ibadan, Nigeria

Received: 09 May 2024
Revised: 16 June 2024
Accepted: 07 June 2024

***Correspondence:**
Dr. Olanike O. Balogun,
E-mail: balogun.olanike@lcu.edu.ng

Copyright: © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

Background: The nutritional and phytochemical content of cassava has shown many health benefits. However, the use of cassava for the control of diabetes and dyslipidemia is poorly researched. Hence this study aims to determine the effect of cassava flour fortified with pumpkin leaves on post-prandial blood glucose level.

Methods: The research adopted an experimental study design. The fortified cassava flour was produced at International Institute of Tropical Agriculture, Ibadan, Oyo State, Nigeria. The flour was fortified in the ratio; 90:10 (sample-A), 70:30 (sample-B), and 50:50 (sample-C). The fasting and postprandial plasma of the subjects were taken using Rossmax and Accu Checker. The proximate and micronutrient composition of cassava were analyzed. The data analysis was carried out using the IBM SPSS Statistics, version 25.

Results: The result of the post-prandial effect (min/max) of control, sample A, B, and C, was 57/310 mg/dl, 102/282 mg/dl, 79/188 mg/dl, and 74/160 mg/dl respectively. Sample-B had the highest value in ash, protein, and crude fiber contents. Sample-C had the least protein. The control sample had the least fiber content. sample-A had the highest fat content. However, sample-B had the highest percentage of carbohydrate [96.89±0.03 (sample-B), 84.01±0.19 (sample-C), 83.32±0.02 (Control), and 79.35±0.75 (sample-A)]. The micro-nutrient of the control is lower than other samples with the exception of phosphorus. Sample-A had the highest value of potassium, iron, and calcium. Sample-B had the highest value for magnesium and phosphorus.

Conclusions: Sample-C had a lowering effect on the post-prandial blood level of the respondents.

Keywords: Fortification of cassava, Diabetes management, Medical nutrition therapy, Food-food fortification, Hyperglycemia, Pumpkin leaves

INTRODUCTION

Diabetes mellitus (DM) is a long-term metabolic illness defined by high blood sugar levels arising from a deficit or ineffectiveness of insulin, which leads to changes in the metabolism of lipids, proteins, and carbohydrates, as well as organ system failure.[1] The incidence of DM is growing in individuals that were previously untouched or minimally affected, creating a substantial challenge to government and charity healthcare financing. The International Diabetes Federation (IDF) states that there are 425 million persons worldwide who have diabetes (DM), with more than half of them staying undiagnosed.[2] This statistic provides the most up-to-date information on prevalence. In 2014, the World Health Organization (WHO) recorded that there were 424.9 million persons with diabetes. It is estimated that by 2045, this number will climb to 628.6 million.[3] According to data, the prevalence of diabetes among adult Nigerians aged 20 to 69 is presently 1.7%.[2]

Due to the IDF's dependence on extrapolated data from other countries, there is a common perception that their prevalence numbers grossly underestimate the real burden of diabetes mellitus in Nigeria. Recently, several experts have reported varied rates of incidence in Nigeria, ranging from 2% to 12%.[4]

Managing diabetes mellitus may be done by strengthening patients' knowledge, attitudes, and actions linked to their diet. These elements are acknowledged as key components of all-encompassing diabetes care.[5] Research on the nutritional and phytochemical composition of cassava has proven diverse therapeutic benefits in the field of health. However, all of the papers have one thing in common: none of them advocate employing cassava to treat dyslipidemia and diabetes.[6] Despite the assumption that cassava may be a better choice for diabetics than wheat and white potatoes, there is no scientific evidence in the literature supporting the use of cassava to treat diabetes and dyslipidemia.[6]

Furthermore, the therapeutic benefits of a high-fiber diet are obvious, yet patients with diabetes are being discouraged from taking cassava in favor of wheat. There has been a disturbance about cassava.[6] Although cassava has a variety of compounds that are thought to be poisonous to humans, over 80% of them are eliminated during the tuber's processing.[7] Because they consist of multiple biochemical components, several traditional foods, such as root and tuber crops, have been proved to be especially crucial in the worldwide treatment of diabetes.[8] The Food and Nutritional Investigation Institute did a short-term investigation to analyze the glycemic index and cholesterol-lowering potential of root and tuber crops. The results suggested that these crops had a low GI (GI<55) due to their slow release of glucose into the blood.[6] The findings suggest that root and tuber crops may be useful to health in lessening the risk of chronic diseases including diabetes mellitus and cardiovascular disease.

According to research, the thought of employing cassava to produce dietary fiber supplements may be appealing in addition to enhancing the nutritious value of a meal heavy in carbohydrates.[6] Furthermore, the creation and utilization of fortified cassava flour may be viewed as an extra strategy to aid consumers accessibility and complete their everyday nutritional demands.[9] A characteristic vegetable growing all around the globe is the pumpkin. It is a member of the *Cucurbitaceae* family, one of the greatest plant groups in the plant world, and the genus Cucubita.

The nutritional content and health advantages of pumpkin flesh, seeds, and leaves have gained extensive study in recent decades. It has been demonstrated by past investigations that the leaves of the pumpkin (Telfaria occidentalis, family *Cucurbitaceae*) are similarly highly concentrated in lipids, proteins, oils, minerals, and vitamins.[10] In identical rat settings, methanol preparations from pumpkin leaves demonstrated a substantial drop in blood glucose.[11] Additionally, research has been done on the bioactive chemicals present in pumpkin seeds and leaves and how they affect distinct blood glucose-lowering pathways. Pumpkin leaves, on the other hand, are rich in flavonoids, phenols, alkaloids, tannins, glycosides, and steroids, among other bioactive components.[11]

It makes it rational to add vitamins to cassava flour fortification. Nigeria is the world's biggest producer of cassava, which is an essential staple and cash crop that feeds about a billion people worldwide.[12] Therefore, regardless of socioeconomic level, fortifying cassava flour, a basic meal that is regularly consumed, has the potential to drastically boost the nutritional quality of a broad portion of the population.[13]

The findings of this research will contribute to the growing body of information about the beneficial benefits of diet in the control of diabetes and help those with elevated blood sugar levels to maintain their glucose levels without having to entirely give up their natural meals because of fortification. Additionally, the conclusions of this research will boost public health and help prevent micronutrient deficiencies while offering no damage to anyone's health. Thus, the purpose of this research was to fortify cassava flour with pumpkin leaves and assessed its impact on the level of blood glucose after a meal.

METHODS

The study design was an experimental study. The production of fortified cassava flour and study experiment were carried out from March, 2022 to July, 2022. The research was carried out among eighteen diabetes patients who volunteered and were part of the Diabetes Association of Nigeria (DAN) in the medical out-patient unit of University College Teaching Hospital, UCH Ibadan.

Inclusion criteria

Patients attending the medical out-patient unit of University College Teaching Hospital (UCH) Ibadan and were members of the Diabetes Association of Nigeria. Patients who are diagnosed of diabetes. Patients who volunteered to participate in the study.

Exclusion criteria

Non-diabetes patients. Patients who did not volunteer to participate in the study. Patients who are not attending the medical out-patient unit of UCH Ibadan.

Ethical consideration

A letter of introduction was submitted to the Diabetes Association of Nigeria, UCH. An ethical approval with reference number, LCU-REC/22/060 was obtained from the Lead City University, Ibadan. Informed written consent was obtained for and signed by the participants for the study. Confidentiality was ensured throughout the study.

Materials procurement

The cassava was obtained and processed at International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State, Nigeria. The pumpkin leaf was obtained from one of the nearby local markets in Ibadan, Oyo State, Nigeria.

Food preparation and processing

All preparation and processing regarding the production and fortification of cassava flour were carried out in International Institute of Tropical Agriculture, Ibadan, Oyo State.

Processing of cassava flour

Cassava tubers were obtained, produced and processed at International Institute of Tropical Agriculture, Ibadan, Oyo State, Nigeria. The fresh roots were peeled manually with knife. The peeled roots were washed and chopped into small pieces. Thereafter, they were soaked into water for 5 days to soften it. After 5 days, the cassava was packed in a sack and pressed, using hydraulic jack to drain the water. They are oven-dried 3 days at temperature 70°C. After drying, the cassava was milled into flour.

Processing of pumpkin leaves

The pumpkin leaves were plucked, rinsed and air-dried for 1hour to avoid steaming of the leaves instead of drying. Thereafter, the leaves were oven dried for 4 hour 30 minutes at 70°C. The brittle leaves were squeezed and grinded to a powdered form.

Fortification of the cassava flour

The cassava and pumpkin leaves were mixed and portioned in different ratios; 70:30, 90:10, and 50:50. There was also a portion of cassava flour containing no pumpkin vegetable which serve as the control.

Preparation of cassava dough

The four samples of cassava flour, including the control sample, were made into dough. The cassava flour was sieved before use. In a pot, boiled water was poured and the cassava flour was added immediately. The mixture was stirred till cassava flour became incorporated. It was continuously stirred till the dough became smooth and lump free.

Preparation of fish

The fish was grilled for about half an hour.

Preparation of jute leaves

The jute leaves (ewedu) were prepared with locust beans inside of it.

Preparation of soup

The soup was prepared using moderate quantity of palm oil and seasonings.

Experimental procedure

The subjects ingested the three ratios of fortified cassava flour and a reference meal which is the non-fortified flour (control). One meal-type was served to all participants in the first session, which is day 1 (reference meal). Ten subjects were selected randomly and served for the remaining three sessions as follows: day 2 (90:10), day 3 (50:50), and day 4 (70:30). Each test meal was portioned once with each serving containing 300 g of the cassava dough with 500 ml jute leaves soup, medium-sized fish and 250 ml soup.

Data collection

The respondents' weight, height, waist circumference, and hip circumference were measured to determine their BMI and waist-to-hip ratio. The fasting and postprandial blood glucose levels of the subjects were taken using Rossmax and Accu Checker.

Food proximate nutrient composition and calorie analysis

The nutrient composition of cassava; protein, fat, crude fibre, ash and moisture content, was determined on a dry matter basis. Protein content was determined using kjeldal method and nitrogen content of the samples was multiplied by a factor 6.25. The dry matter and ash content of fresh cassava roots was of the Association of Official Analytical Chemists. Crude fat was determined by the method of using an Automated FOSS soxhlet System 8000 and Soxhlet extraction.

A colorimetric method was used to determine the starch content. The mixture was vortexed and centrifuged at 2000 rpm for 10 min. The residue was hydrolyzed with perchloric acid to determine starch content, and the supernatant was used to estimate sugar. The phenol-sulphuric acid reagent was used for colour development. The absorbance of the colored compounds is read on a UV-Vis spectrophotometer (Genesys 101S UV-Vis Spectrophotometer) at wavelength of 490 nm and quantified using glucose standard curve.

Data analysis

All analyses were carried out using the IBM SPSS Statistics, version 25. Data obtained were summarized using descriptive statistics; means and standard deviations, while the independent t-test and One-way analysis of Variance (ANOVA) were used to test for the mean differences of selected parameters between the samples and variable groups. Level of significance was set at 5%.

RESULTS

The mean moisture content was higher in sample-C (p=0.006). The mean ash content was higher in sample-B, 4.49±0.01% and lower in sample-C, 0.79±0.01%. The crude fibre content of sample-B was found to be higher (2.11±0.02%). The mean carbohydrate content of sample-B was higher (96.89±0.03%) with sample-A having the least value (79.35±0.75%). The control sample had the highest amylose content (30.55±0.35%) while sample B had the least content (13.21±0.29%).

Sample-B had the highest amylopectin content (86.79±0.29%) while sample-C amylopectin content was 75.09±0.19%. The sugar content of sample-C is lower (5.08±0.15%) compared to other samples while its mean starch content was 85.90±0.29% (Table 1).

Table 1: Proximate analysis of the samples (%) (mean±SD).

	Control	Sample A	Sample B	Sample C	P value
Moisture	10.77±0.00	10.61±0.09	10.36±0.09	10.84±0.20	0.006*
Ash	1.35±0.03	2.99±0.00	4.49±0.01	0.79±0.01	0.000*
Fat	1.21±0.05	2.25±0.16	1.61±0.14	0.95±0.13	0.002*
Protein	2.12±0.03	3.39±0.01	4.55±0.01	2.01±0.04	0.000*
Crude Fibre	1.23±0.01	1.42±0.01	2.11±0.02	1.41±0.02	0.000*
Carbohydrate	83.32±0.02	79.35±0.75	96.89±0.03	84.01±0.19	0.000*
Amylose	30.55±0.35	14.31±0.49	13.21±0.29	24.91±0.19	0.000*
Amylopectin	69.45±0.35	85.69±0.49	86.79±0.29	75.09±0.19	0.000*
Sugar	6.70±0.04	7.54±0.43	6.46±0.20	5.08±0.15	0.002*
Starch	89.53±0.42	78.60±0.28	87.61±0.16	85.90±0.29	0.000*

* - Statistically significant

Table 2: Characteristics of subjects studied (n=18) (mean±SD).

Parameter	Male	Female	P value
Age (years)	67.86±3.579	63.73±7.721	0.206
Height (m)	1.64±0.069	1.63±0.069	0.700
Weight (kg)	66.64±11.941	66.86±9.983	0.969
Body Mass Index (kg/m^2)	24.90±3.871	25.22±2.938	0.843
Waist circumference (cm)	91.00±7.789	97.18±9.304	0.164
Hip circumference (cm)	97.73±5.867	99.29±9.032	0.661
Waist-Hip-Ratio	0.93±0.089	0.99±0.08	0.125

Table 3: Effect of fortified flour on postprandial blood glucose.

Sample	FBG (mg/dl)		2 hours PP (mg/dl)	
	Mean±SD	Min/max	Mean±SD	Min/max
Control	114.28±26.753	81/200	148.22±58.435	57/310
Sample A	118.30±15.305	97/137	165.80±55.912	102/282
Sample B	108.56±10.690	89/120	142.78±36.799	79/188
Sample C	116.50±27.375	70/174	120.60±29.022	74/160

Table 1 presented the carbohydrate, crude protein, ash, moisture content, crude fat, crude fiber, amylose, amylopectin, sugar, and starch content of the produced samples.

The mean body mass index (BMI) of females (25.22±2.938 kg/m^2) was higher than for males (24.90±3.871 kg/m^2) (p=-0.843). Similarly, the mean waist circumference of females (97.18±9.304 cm) was higher than for males (91.00±7.789 cm) (p=0.164). The mean hip circumference of females (99.29±9.032 cm) was also higher than for males (97.73±5.867 cm) (p=0.661). The mean waist-hip-ratio of females (0.99±0.08) was higher than for males (0.93±0.089) (p=0.125) (Table 2).

Table 2 described the characteristics of subjects studied which includes age, weight, height, Body Mass Index (BMI), waist circumference, hip circumference, and waist-to-hip ratio of participants of the study.

The fasting blood glucose and post prandial blood glucose of respondents were found to be high on the days when control, sample A, and sample B were consumed while sample C was seen to have a reducing effect on the respondents' blood glucose after 2 hours of consuming the meal (Table 3). The calcium values of sample-A were high (2700.00 mg). Sample-B had the highest value of magnesium, 502.50 mg while sample-B, C, and control had 494.00 mg, and 484.50 mg, and 363.00 mg, respectively. The iron content of sample was high (16.62 mg), sample-C had 9.69 mg iron content while that of control was lower (5.58 mg). Sample-A also had a higher content of potassium (9450.00 mg). The phosphorus content was lower in sample-C (14.53) but higher in sample-B (188.91 mg) while sample-A and control has 133.20 mg and 79.92 mg respectively (Figure 1 A, B, C, D, and E).

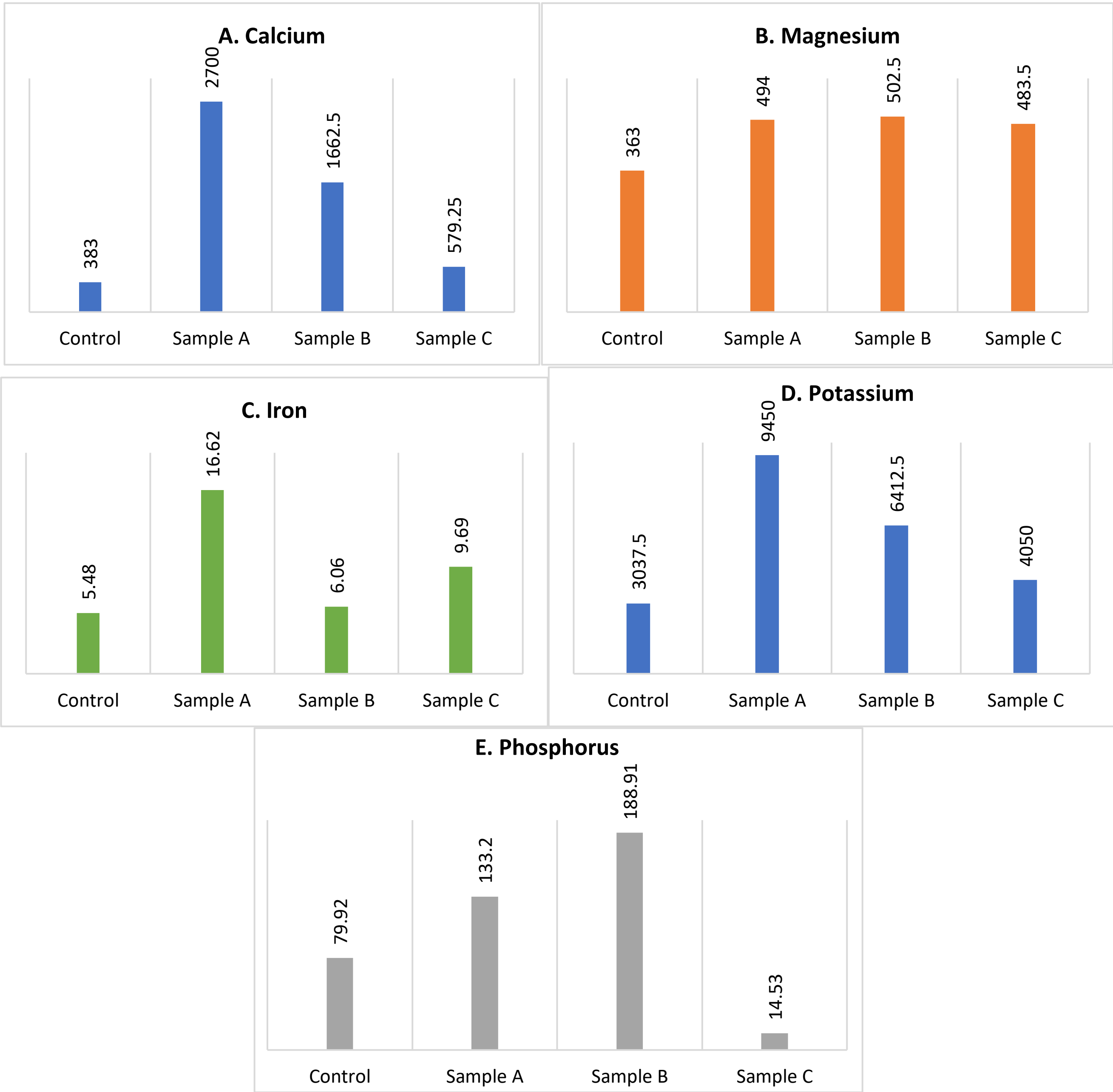

Figure 1 (A-E): Micronutrient analysis of the samples.

DISCUSSION

This study assessed the nutritional content and influence of adding fluted pumpkin to cassava flour on the postprandial blood glucose levels of people over the age of forty. Upon doing a proximate analysis on the numerous samples of fortified cassava flour, the findings indicated that there were variances in every feature. The ranges for moisture content were 10.36-10.84%, ash, fat, protein, and crude fiber were 0.95-2.25%, 2.01-4.55%, 1.23-2.11%, carbohydrate, 83.32-96.89%, sugar, 5.08-7.54%, starch, 13.21-33.55%, and amylopectin was 69.45-86.79%. The observed ranges were typically greater than the findings from a previous investigation.[14]

The study's carbohydrate levels were larger than the previously reported figures, which ranged from 12.90 to 45.80% and from 70.38% to 85.73%, respectively.[14,15] However, the findings of this investigation correspond with those of prior studies that revealed that the range was

87-89%, 96.95%, and 83.55%, respectively.[16-18] Research has revealed the enormous health advantages of dietary fiber in decreasing the risk of chronic illnesses like diabetes mellitus and cardiovascular disease.[6] Fiber may bind to bile acids and hinder the liver from reabsorbing them, which prevents the synthesis of cholesterol. Dietary fiber's bitter and fibrous structure helps control blood glucose levels over time, which assists in the successful treatment and management of obesity and diabetes mellitus.[6] In this study, it was revealed that sample B had a greater fiber content than the control sample. Like a wick, fiber may absorb water rapidly; nevertheless, because the water is ill-bound in the fiber structure, it may readily exit during drying, reducing the moisture content. This could give an explanation for sample B's lower moisture content than other samples.

The food industry has identified that one key element that may make gel is cassava starch. This occurs as a consequence of its capacity to bind and sustain the textural properties of food components.[19,20] Every sample utilized in this experiment had a high starch content. This conclusion is consistent with past studies that indicated that when averaged, white cassava roots had the greatest starch content and yellow cassava roots the lowest.[21,22]

Amylopectin is rapidly digested, whereas amylose is tougher to hydrolyze. According to the present analysis, sample B had a lower amylose level than the other samples, but greater amylopectin concentration. A previous experiment indicated that a greater amylopectin level was connected to increased nutritional digestibility and an increased postprandial glucose-insulin response.[23]

Crude ash level normally fluctuates from 1% to 2% and is an excellent predictor of inorganic elements (minerals including K, Zn, and Ca) in cassava. Food's total mineral composition after it has been burned at a very high temperature is reflected by its ash content. The study's sample ash content is similar to that of a previous examination, which reported a range of 0.89-1.02%.[14] Sample B was determined to have the maximum ash content, whereas sample C had the lowest. This shows that sample B would have a larger mineral content.

The samples' micronutrient analysis indicated that sample A had the greatest quantity of calcium while the control had the lowest. Sample B was found to contain bigger amounts of magnesium and phosphorus than the other samples, all of which had substantial quantities, with the control having the lowest value. As a required component of chlorophyll, magnesium plays a crucial role in the treatment of ischemic heart disease and the metabolism of calcium in bones. Sample A was found to have a substantially larger iron and potassium content than the other samples. A crucial element of hemoglobin is iron.

According to SON guidelines, all samples in this experiment displayed protein levels exceeding the lowest criteria, which are 0.5% for starch and 1.0% for other cassava products. Sample B was determined to have the maximum protein value, whilst sample C had the lowest. The findings of an earlier investigation, which revealed that the sample enriched with more fluted pumpkin had the maximum protein level, and which may be explained by the high protein content in dry vegetable powders, contrast with this conclusion. Studies in the past have indicated that pumpkin leaves have a high protein content.[24,25]

It should be observed that sample A had the biggest fat content and sample C had the lowest. This shows that sample A would have the most pleasant flavor out of the four samples, while sample C would have the least appetizing taste. Because fat promotes palatability, this is the case.[24,25]

But sample A has a larger sugar content than sample C does. This conclusion contradicts a study that indicated that non-fertilized TME 419 cassava species had a lower value for soluble sugar.[26] The increased number of pumpkin leaves in sample C is the explanation for its lower sugar concentration.

The respondents' BMI and waist-to-hip ratio were also examined in this investigation. It was revealed that women had higher mean body mass indices (BMIs) and waist-to-hip ratios than males. Since diabetes mellitus is a metabolic endocrine disorder, it is strongly connected to the metabolism of proteins, lipids, and carbohydrates. The association between starchy foods like cassava and the incidence of diabetes mellitus has been the topic of various arguments. Because of this disagreement, patients with diabetes are typically advised to avoid dough manufactured from cassava flour (laafun). Still, several studies have indicated that Africans who take cassava regularly have a low incidence of diabetes. 84% of the 1381 calories eaten were accounted for in an earlier investigate

on, however none of the subjects developed diabetes.[6] The four samples in this experiment were turned into dough, and the two-hour postprandial influence was studied. Before the meal, the respondents' fasting blood sugar levels were assessed. Sample C was revealed to have the least influence on the respondents' postprandial blood glucose levels. Additionally, this figure is compatible with the WHO blood glucose category for diabetics. Its low sugar level, low amylopectin content, and high amylose concentration are the reasons for this. In addition to the vegetables that were incorporated into the flour, the postprandial effect may have been modified by the inclusion of jute leaves to the soup.

Limitations

The study did not consider the patients' medication in terms of drugs, which was assumed to influence the outcomes. Furthermore, the doughs' glycemic load and index were not verified. The participants' postprandial glucose levels may be influenced by the soup. Therefore, more study should be done while taking all of these into consideration.

CONCLUSION

In conclusion, this study has demonstrated that fortifying cassava flour with fluted pumpkin significantly enhances its nutritional profile and beneficially influences postprandial blood glucose levels. This study offers clarity to previous research by providing scientific evidence supporting the use of cassava in managing diabetes and dyslipidemia, countering the prevalent discouragement of cassava in favor of wheat for diabetic patients. These findings support the strategic incorporation of fluted pumpkin into cassava flour as a practical approach to improving diet quality and effectively managing diabetes, thereby offering a valuable dietary intervention to mitigate the glycemic response and potentially treat dyslipidemia.

ACKNOWLEDGEMENTS

Authors would like to thank the manager, Dr. Peter and the entire staff of Cassava Barn Unit at the International Institute of Tropical Agriculture (IITA) for their guidance and constant supervision as well as for providing necessary information and materials regarding this research. Likewise, the authors appreciate RDN Tunrayo Oduneye and the Diabetes Association of Nigeria (DAN) at Medical Out-Patients Unit, University College Hospital, UCH for their help and cooperation.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. WHO. Definition, diagnosis and classification of diabetes mellitus and its complications, part 1. Geneva: WHO; 1999.
2. International Diabetes Federation. Diabetes atlas. 8th ed. Brussels: International Diabetes Federation; 2017.
3. Standl E, Khunti K, Hansen TB, Schnell O. The global epidemics of diabetes in the 21st century: Current situation and perspectives. European Journal of Preventive Cardiology. 2019;26(2):7–14.
4. Gezawa ID, Puepet FH, Mubi BM, Uloko AE, Bakki B, Talle MA, et al. Socio-demographic and anthropometric risk factors for type 2 diabetes in Maiduguri, North-Eastern Nigeria. Sahel Med J. 2015;18(5):1–7.
5. Islam SM, Niessen LW, Seissler J, Ferrari U, Biswas T, Islam A, et al. Diabetes knowledge and glycemic control among patients with Type 2 diabetes in Bangladesh. Springerplus. 2015;4:284.
6. Bonaventure CO, Richard JC, Ezekiel, UN. Facts about dietary fibre in cassava: Implication for diabetes' medical nutrition therapy. Integrative Food Nutrition Metabolism. 2018;5(3):1-5
7. Onodu BC, Culas RJ, Nwose EU. Health values of cassava compared to wheat and yam: A critical review of carbohydrate/fibre and fat/fibre ratios. In: Logotheti A, Babu GA, Seo D (eds.) 6th International Conference on Research in Chemical, Agricultural & Biological Sciences (RCABS-2017) Singapore, 2017: 180-2.
8. Oluwamukomi MO. Chemical and sensory properties of gari enriched with sesame seed flour (Sesamum indicum L). FUTA Journal of Research in Sciences. 2015;1:123-31.
9. Louise A. Fortified cassava flour: development of an international specification. Natural Resources Institute; 2022.
10. Mohd A, Idris M, Abdulrasheed A. The Mineral Composition and Proximate Analysis of T. occidentalis (Fluted Pumpkin) Leaves Consumed in Kano Metropolis, Northern Nigeria. American Chemical Science Journal. 2016;10(1):1–4.
11. Abubakar AN, Badmos FO, Saidu AN, Yunus IO, Hamzah RU, Lawal B. AROC in Natural Product Research. 2021;01(01):52–60.
12. Ikuemonisam ES, Mafimisebi TE, Ajibefun I, Adenegan K. Cassava production in Nigeria: Trends, instability and decomposition analysis (1970–2018). Heliyon. 2020;6(10):e05089.
13. Akinrele IA. Nutritional enrichment for gari (Cassava): West Af J Biol Appl Chem 1967;10(1):19-23.
14. Peprah B, Elizabeth P, Obed H, Angeline B, Matilda S, Maryke L. Proximate composition, cyanide content, and carotenoid retention after boiling of provitamin A-rich cassava grown in Ghana, Foods. 2020;9:1800.
15. Idongesit E, Timothy A, Abel A, Teghtegh S, Ekponoudim E, Dumebi N. Comparative analysis on the proximate composition of processed cassava products obtained from January to March, 2023 in Lafia Town, Nigeria. Chemical Science International Journal. 2023;32(4):50-63.
16. Christopher IN, Enyinnaya CO, Okolie JI, Nkwoada A. The proximate analysis and biochemical composition of the waste peels of three cassava cultivars. Int J Scient Eng Appl Sci. 2016;2:64–71.
17. Tambo TS, Klang JM, Ndomou H, Teboukeu B, Womeni HM. Characterization of corn, cassava, and commercial flours: use of amylase-rich flours of germinated corn and sweet potato in the reduction of the consistency of the gruels made from these floursinfluence on the nutritional and energy value. Food Science and Nutrition. 2019;7(4):1190–206.
18. Dudu OE, Ma Y, Adelekan A, Oyedeji AB, Oyeyinka SA, Ogungbemi JW. Bread-making potential of heatmoisture treated cassava flour-additive complexes. International Journal of Biological Macromolecules. 2020;130:109477.

19. Fortuna T, Gakowska D. Modified starches as food additives (in Polish). Laboratorium Przegl'd Ogolnopolski. 2006;8(2006):38-41.
20. Gu B, Yao Q, Li KM, Chen SB. Change in physiological traits of cassava roots and starches associated with genotypes and environmental factors. Starch-Starke. 2013;65:253-63.
21. Maziya-Dixon B, Adebowale AA, Onabanjo OO, Dixon AGO. Effects of variety and drying methods on physio-chemical properties of high quality cassava flour from yellow cassava roots. In African Crop Science Conference Proceedings, African Crop Science Society, Kampala, Uganda. 2005;10:635-41.
22. Aniedu C, Omodamiro RM, Use of newly bred β-carotene cassava in production of value-added products: implications for food security in Nigeria. Glob J Sci Front Res Agric Vet Science. 2012;12:10-6.
23. Xiaoqian G, Bing Y, Jie Y, Xiangbing M, Zhiqing H, Yuheng L, et al. Effects dietary starch structure on growth performance, serum glucose-insulin response, and intestinal health in weaned piglets. Animals. 2020;10(3):543.
24. Sanne B, Deidre Mc M, Valentine U. Patterns and determinants of fruit and vegetable consumption in urban Rwanda: results of an urban consumer study in Kigali and Northwestern Rwanda. Wageningen Centre for Development Innovation, Wageningen; 2020.
25. Olaoye OA, Onilude AA, Idowu OA. Quality characteristics of bread produced from composite flours of wheat, plantainandsoybeans. African Journal of Biotechnology. 2016;11(5):1102–6.
26. Rasaq A, Taofiq S, Adebayo A, Gbemisola F, Omoniyi O. Effect of cassava variety, fertilizer type and dosage on the physiochemical, functional and pasting properties of high-quality cassava flour (HQCF). Quality Assurance and Safety of Crops & Foods. 2020;12(1):18-27.

Cite this article as: Balogun OO, Olaniran OP, Oduneye MT. Nutrient composition of cassava flour fortified with pumpkin leaves and its effects on post-prandial blood glucose level among diabetes patients. Int J Community Med Public Health 2024;11:2606-13.