Contemporary Journal of Advancement in Food Science and Technology
Volume.10, Number 1; January-March 2024;
ISSN: 2836-8207 | Impact Factor: 7.62
https://zapjournals.com/Journals/index.php/cjafst
Published By: Zendo Academic Publishing

INVESTIGATING THE QUALITY TRAITS OF FUFU DERIVED FROM CASSAVA MOSAIC DISEASE (CMD) RESISTANT GENOTYPES

[1]Chika Okeke and [2]Emmanuel Nwosu
[1]Research Scientist, National Root Crops Research Institute (NRCRI), Umudike, Abia State, Nigeria and [2]Professor, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.

Article Info
Keywords: Cassava, Staple food crop, Food security, Breeding programs, Cyanide toxicity

DOI
10.5281/zenodo.10683310

Abstract
Cassava (Manihot esculenta) stands as a vital staple food crop across tropical regions in Africa, Asia, and Latin America, serving as a cornerstone of nutrition for millions of people. Its significance is underscored by estimates suggesting that cassava provides approximately 40% of the total calories consumed in Africa, making it second only to cereal grains in terms of energy contribution to the Nigerian diet. While cassava roots are predominantly composed of carbohydrates, with starch accounting for 80% of its content and minimal fat, it is notable for its low protein content (1.20%) and variable cyanide levels, with certain varieties such as TMS 50395 containing cyanide levels exceeding 10 mg/100 g fresh weight. Despite these nutritional constraints, cassava plays a pivotal role in mitigating the African Food Crisis.

The development of the NR8082 cassava variety by the National Root Crops Research Institute, Nigeria, signifies a significant breakthrough in cassava breeding efforts. This low-cyanide, high-yielding variety has been widely distributed to Nigerian farmers, offering a promising solution to enhance cassava productivity while mitigating the risks associated with cyanide toxicity. Through targeted breeding programs and research initiatives, such as the development of cyanide-resistant varieties like NR8082, efforts are underway to improve the nutritional profile and agronomic performance of cassava, thereby bolstering food security and livelihoods in resource-constrained regions.

This paper highlights the critical importance of cassava as a staple food crop and the role of breeding programs in enhancing its nutritional quality and yield potential. By leveraging scientific advancements and collaborative partnerships, researchers and agricultural stakeholders

can work towards developing resilient cassava varieties that address both nutritional deficiencies and production challenges, thereby contributing to sustainable food systems and livelihoods in tropical regions.

Abstract:
Keywords:

INTRODUCTION

Cassava (*Manihot esculenta*) is an important staple food crop for millions of people in the tropical areas of African, Asia and Latin America. It is estimated (IITA,1990) that the crop provides about 40% of all the calories consumed in Africa and ranks second only to cereal grains as chief source of energy in Nigerian diet (Ngoddy, 1989). Cassava roots contain mainly carbohydrates, of which 80% is starch and >1% fat (Goomez, 1979). By this, cassava plays important role in alleviating African Food Crisis though poor in protein (1.20%) and rich in cyanide (> 10 mg/100 g fresh weight) in some varieties such as TMS 50395 (IITA,1990). The NR8082 cassava variety with low -cyanide high- yielding quality developed by the National Root Crops Research Institute, Nigeria, has commonly been distributed to Nigerian farmers (Nwabueze and Odunsi, 2007). However, Nigeria's cassava output is now threatened by a virulent form of the Cassava Mosaic Disease (CMD) advancing rapidly from East Africa (IITA, 2005). This is what initiated the pre-emptive management of CMD project by the International Institute of Tropical Agriculture (IITA) primarily to develop Cassava Mosaic Disease resistant varieties. Consequently, about 45 new CMD resistant varieties have been developed (Nwabueze and Anoruoh, 2008).

In Nigeria, rapid urban growth and development place a dynamic challenge to cassava products and market development for cassava foods will continue to increase. Although cassava roots are processed by several traditional methods, which vary widely from region to region into products such as *gari, lafun, landang, fufu,* flour, chips, starch *akara, okpokpo garri,* meal*, ighu,* syrups, dextrins, and alcohol (Nwabueze and Odunsi, 2007), high quality cassava flour that can replace wheat and other imported flours in tropical countries (Wheatley and Best, 1991) has been reported. Production of *fufu* of acceptable standard from the CMD resistant varieties has not been adequately reported in literature. The objective of this research was to produce and evaluate *fufu* flour and dough from 43 CMD resistant varieties, in terms of their proximate composition, functional and pasting properties. It is expected that the result obtained from the study will contribute in providing information on these CMD resistant varieties and also serve as a guide for future research and improvement of these new cassava varieties.

Table 1. Forty three 10-12 months old CMD resistant varieties harvested from the field trial of NRCRI, Umudike.

CMD		CMD		CMD	
S/n	**Varieties**	**S/n**	**Varieties**	**S/n**	**Varieties**
1.	97/4769	16.	TME 419	30.	92/0057
2.	99/6012	17.	96/0603	31.	91/0166
3.	94/0561	18.	98/2226	32.	96/1089A
4.	97/0162	19.	82/005	33.	96/1314
5.	94/0026	20.	97/0211	34.	97/3200
6.	96/1642	21.	95/0289	35.	98/0040
7.	98/0510	22.	92/0326	36.	TMS 30572

8.	98/0505	23.	4(2)1452	37.	99/2123
9.	99/3037	24.	98/0002	38.	92/0067
10.	98/2101	25.	97/4779	39.	97/0039
11.	97/4763	26.	96/1632	40.	95/0379
12.	97/2205	27.	96/0523	41.	92B/0061
13.	98/1565	28.	M98/0068	42.	98/0581
15.	92B/0068	29.	M98/0028	43.	96/1569

NRCRI = National Root Crops Research Institute and CMD = Cassava Mosaic Disease resistant varieties.

MATERIALS AND METHODS

Source of raw materials

Forty three Cassava Mosaic Disease resistant (CMD) varieties were harvested at 10 - 12 months old from the field trial of National Root Crops Research Institute (NRCRI), Umudike, Abia State, Nigeria (Table 1).

Production of *fufu* flours

Cassava *fufu* flours were produced from each of the CMD resistant varieties using the processing methods described by Okpokiri et al. (1984). The cassava roots were washed, peeled and re-washed with clean borehole water. They were steeped in water in a 1:2 (v/v) for 48 h. At the end of the steeping period the cassava samples were re-washed and grated into pulp using the IITA MK powered grater (3.5HP petrol engine, Lambourn, LTD, Corydon, CR93EE, United Kingdom).

Each cassava pulp sample was re-steeped in water for another 24 h to ferment. The fermented pulp was sieved with Endescotts laboratory test sieve with an aperture size of 2.0 mm (Endescotts laboratory Test sieve London, United Kingdom). Recovered samples were packed in bags and de-watered using a John Willy and Sons hydraulic press (7.5HP, John Willy and Sons LTD, United Kingdom). The resulting cassava cake was pulverized by hand and sun-dried on a wide opaque water-proof spread (Jiffy bags macro packaging Co., United Kingdom).

The sun-dried sample was mechanically milled into flour of 3.0 mm particle size using a disc attrition mill (2A premier mill, Hunt and Co., United Kingdom). Further sieving was done manually with a *muslin* cloth to obtain fine *fufu* flour. The *fufu* flours obtained from the 43 batches of CMD resistant varieties were properly packaged and sealed in grip-seal polyethylene bags (Gl-model, 2.25” X 2.25”, Jiffy bags macro packaging Co., United Kingdom). Packaged samples were stored at room temperature (28 ± 2ºC) until ready for analysis.

Proximate composition of *fufu* flours

Proximate composition of the 43 CMD *fufu* flours were determined in triplicates for moisture, crude protein (Kjeldhal method), fat (Soxhlet method), and ash according to AOAC (1990). Total carbohydrate was determined by difference. The dry matter content of the flours were calculated and reported as mean values in Table 2 while the proximate values reported on wet matter basis is shown in Table 3.

Functional properties

Water absorption capacity (WAC) of the *fufu* flour samples was determined by the method described by Okaka and Porter (1979) while the bulk density was determined using the method described by Okezie and Bello (1988).

Pasting properties

Pasting properties of the *fufu* flours were determined with the aid of a Rapid Visco Analyzer (RVA 3D+, Network Scientific Unit, SNW 2102, Australia). Parameters determined were final viscosity, set back viscosity, pasting time and pasting temperature.

Statistical analysis

Data obtained from the analyses of the *fufu* flour samples were subjected to statistical analysis using Statistical Analytical System (SAS, 1999) software package. Analysis of variance (ANOVA) was done and means separation using Fischer LSD to determine significant differences at 5 % probability was done.

RESULTS AND DISCUSSION

Proximate composition

Table 2 shows the moisture, dry matter and energy content of *fufu* flours produced from 43 CMD resistant varieties in Umudike. Moisture content ranged from 5.52% in *fufu* flour made from the CMD 97/4769 variety to 12.25% in the 96/1569 variety. The reverse was the case for their dry matter contents being 94.48 and 87.75% respectively. The generally low moisture content of the *fufu* flours is an indication of a good stable shelf life if packaged and stored. This is because with this moisture range, the quality of the final product will not be adversely affected. Furthermore, high moisture products require further costly drying operations to allow easy handling and storage (Sefa – Dedeh and Saalia, 1997). Values of moisture contents were within the recommended standard of 13 % (m/m) for edible cassava flour (Sanni et al., 2005).

The high dry matter is an indication of desirable quality attributes in the CMD resistant varieties. Such attributes like good yields, diseases and pest tolerance, high root

Table 2. Moisture and dry matter content of *fufu* flours produced from 43 CMD resistant varieties in Umudike

Table 3.

Cassava cultivar	Moisture content (%)	Dry matter content (%)	Energy (kcal/g)
97/4769	5.52 ± 0.02	94.48 ± 0.02	375.08± 0.03
99/6012	6.17 ± 0.01	93.83 ± 0.01	375.40± 0.04
94/0561	6.51 ± 0.01	93.49 ± 0.01	374.95± 0.03
97/0162	6.97 ± 0.02	93.03 ± 0.02	373.74± 0.02
94/0026	6.99 ± 0.04	93.01 ± 0.04	373.48± 0.04
96/1642	7.02 ± 0.02	92.98 ± 0.02	376.20± 0.12
98/0510	7.26 ± 0.04	92.74 ± 0.04	371.83± 0.04
98/0505	7.29 ± 0.02	92.71 ± 0.02	371.40± 0.02
99/3037	7.45 ± 0.02	92.55 ± 0.02	362.82± 0.03
98/2101	7.46 ± 0.02	92.54 ± 0.02	361.94± 0.06
97/4763	7.48 ± 0.01	92.52 ± 0.01	369.55± 0.04
97/2205	8.19 ± 0.03	91.81 ± 0.03	367.68± 0.12
98/1565	8.19 ± 0.01	91.81 ± 0.01	365.06± 0.02
92/0325	8.22 ± 0.01	91.78 ± 0.01	367.28± 0.06
92B/0068	8.32 ± 0.02	91.68 ± 0.02	365.54± 0.04
TME 419	8.32 ± 0.56	91.68 ± 0.56	366.79± 0.03
96/0603	8.37 ± 0.02	91.63 ± 0.02	377.27± 0.06
98/2226	8.62 ± 0.02	91.38 ± 0.02	365.30± 0.03
82/0058	8.70 ± 0.02	91.3 ± 0.02	370.50± 0.12
97/0211	8.70 ± 0.20	91.3 ± 0.20	361.00± 0.04
95/0289	9.09 ± 0.03	90.91 ± 0.03	364.78± 0.02
92/0326	9.13 ± 0.02	90.87 ± 0.02	364.60± 0.04
4(2)1452	9.14 ± 0.03	90.86 ± 0.03	361.44± 0.03

98/0002	9.32 ± 0.01	90.68 ± 0.01	362.85± 0.12
97/4779	9.35 ± 0.02	90.65 ± 0.02	360.66± 0.03
96/1632	9.35 ± 0.12	90.65 ± 0.12	363.44± 0.02
96/0523	9.43 ± 0.03	90.57 ± 0.03	365.21± 0.03
M98/0068	9.53 ± 0.01	90.47 ± 0.01	361.77± 0.12
M98/0028	9.55 ± 0.01	90.45 ± 0.01	362.40± 0.04
96/1089A	9.57 ± 0.02	90.43 ± 0.02	359.91± 0.03
91/0166	9.63 ± 0.02	90.37 ± 0.02	357.60± 0.02
92/0057	9.66 ± 0.06	90.34 ± 0.06	361.19± 0.03
96/1314	9.78 ± 0.01	90.22 ± 0.01	358.33± 0.03
97/3200	9.78 ± 0.05	90.22 ± 0.05	361.72± 0.02
98/0040	9.96 ± 0.03	90.0 ± 0.03	359.94± 0.04
TMS 30572	10.13± 0.05	89.87 ± 0.05	359.25± 0.03
99/2123	10.26 ± 0.03	89.74 ± 0.03	359.61± 0.06
92/0067	10.38 ± 0.02	89.62 ± 0.02	358.36± 0.04
97/0039	10.39 ± 0.01	89.60 ± 0.01	357.22± 0.03
95/0379	10.45 ± 0.02	89.55 ± 0.02	358.31± 0.12
92B/0061	10.65 ± 0.01	89.35 ± 0.01	316.80± 0.04
98/0581	11.26 ± 0.04	88.74 ± 0.04	312.78± 0.03
96/1569	12.25 ± 0.02	87.75 ± 0.02	350.25± 0.12

Yields (fresh and dry) meet end-users characteristics (IITA, 2005). Dry matter is a practical approach to improving the shelf life and marketability of fufu flour (Akingbala et al., 1991).

The energy content ranged from 357.22 in the 97/0039 CMD variety to 377.27 cal/kg in the 96/0603 variety. These varieties have 10.39 and 8.37% moisture and 89.60 and 91.63% dry matter contents respectively.

Protein, ash and fat contents were generally low while carbohydrate contents were high (Table 3). The composition showed varied significant differences with the mean ged from 0.35% (M98/0028) to 2.88% in some varieties. values of ash and crude fibre being less than the maxi- The low protein of fufu flours is not a serious issue as fufu mum Codex standard for edible cassava flour (3.0 and is usually consumed accompanied with different protein 2.0% respectively) (FAO, 1995). The protein content ran- sources both of animal and vegetable origin.

Proximate composition of *fufu* flours processed from CMD resistant varieties in Umudike.

Cassava variety	Protein (%)	Ash (%)	Fat (%)	Fibre (%)	Carbohydrate (%)
97/4769	2.45 ±0.04	0.64 ± 0.01	0.41± 0.06	0.07 ± 0.03	90.91 ± 0.04
99/6012	1.93 ±0.03	0.64 ± 0.03	0.24± 0.03	0.06 ± 0.01	91.38 ± 0.02
94/0561	1.4 ±0.02	0.22 ± 0.01	0.51± 0.02	0.07 ± 0.02	91.19 ± 0.01
97/0162	2.07 ±0.06	0.32 ± 0.03	0.58± 0.03	0.05 ± 0.02	90.06 ± 0.04
94/0026	1.40 ± 0.02	0.24 ± 0.02	0.56± 0.01	0.04 ± 0.01	90.71 ± 0.01
96/1642	2.55 ± 0.05	0.39 ± 0.01	0.40± 0.02	0.04 ± 0.02	90.60 ± 0.02
98/0510	1.82 ± 0.03	0.07 ± 0.02	0.27± 0.03	0.05 ± 0.01	90.53 ± 0.02

98/0505	2.45 ± 0.02	0.05 ± 0.03	0.20± 0.02	0.06 ± 0.01	89.95 ± 0.03
99/3037	2.15 ± 0.01	0.59 ± 0.01	0.42± 0.01	0.01 ± 0.01	87.61 ± 0.03
98/2101	1.93 ± 0.05	2.52 ± 0.02	0.42± 0.01	0.06 ± 0.05	87.37 ± 0.03
97/4763	2.41 ± 0.13	0.37 ± 0.04	0.23± 0.03	0.05 ± 0.02	89.46 ± 0.02
97/2205	1.40 ± 0.02	0.34 ± 0.01	0.40± 0.01	0.05 ± 0.01	89.62 ± 0.02
98/1565	0.70 ± 0.02	0.51 ± 0.04	0.34± 0.01	0.07 ± 0.01	89.80 ± 0.03
92/0325	1.75 ± 0.02	0.10 ± 0.01	0.12± 0.02	0.01 ± 0.01	89.80 ± 0.30
92B/0068	1.23 ± 0.01	0.20 ± 0.02	0.66± 0.01	0.03 ± 0.03	88.67 ± 0.02
TME 419	0.70 ± 0.04	0.41 ± 0.01	0.39± 0.02	0.06 ± 0.01	90.12 ± 0.03
96/0603	0.98 ± 0.02	0.22 ± 0.02	0.39± 0.01	0.08 ± 0.01	89.96 ± 0.01
98/2226	2.80 ± 0.02	0.45 ± 0.03	0.34± 0.04	0.03 ± 0.02	87.76 ± 0.03
82/0058	1.78 ± 0.01	1.58 ± 0.08	0.34± 0.01	0.02 ± 0.01	87.58 ± 0.03
97/0211	2.80 ± 0.20	1.53 ± 0.31	0.56± 0.01	0.03 ± 0.03	86.19 ± 0.01
95/0289	1.78 ± 0.01	0.22 ± 0.03	0.42± 0.01	0.02 ± 0.01	88.47 ± 0.02
92/0326	2.80 ± 0.02	0.34 ± 0.04	0.56± 0.01	0.08 ± 0.06	87.09 ± 0.02
4 (2) 1452	1.40 ± 0.02	1.28 ± 0.01	0.64± 0.01	0.02 ± 0.01	87.52 ± 0.02
98/0002	1.78 ± 0.01	0.43 ± 0.01	0.41± 0.02	0.04 ± 0.03	88.01 ± 0.01
97/4779	2.10 ± 0.01	0.97 ± 0.02	0.42± 0.01	0.04 ± 0.02	87.12 ± 0.01
96/1632	2.80 ± 1.58	0.48 ± 0.07	0.56± 0.01	0.01 ± 0.01	86.80 ± 0.02
96/0523	1.21 ± 0.06	0.44 ± 0.02	0.17± 0.01	0.04 ± 0.02	89.71 ± 0.01
M98/0068	1.05 ± 0.04	0.20 ± 0.02	0.17± 0.01	0.04 ± 0.02	89.01 ± 0.01
M98/0028	0.35 ± 0.03	0.37 ± 0.02	0.44± 0.03	0.03 ± 0.01	89.26 ± 0.02
96/1089A	2.80 ± 0.02	0.94 ± 0.02	0.43± 0.01	0.06 ± 0.01	86.21 ± 0.02
91/0166	2.55 ± 0.05	2.31 ± 3.45	0.30± 0.02	0.03 ± 0.02	86.18 ± 0.04
92/0057	1.05 ± 0.01	0.57 ± 0.02	0.43± 0.01	0.01 ± 0.01	88.28 ± 0.03
96/1314	2.00 ± 0.01	3.34 ± 4.30	0.29± 0.02	0.08 ± 0.01	86.93 ± 0.03
97/3200	1.40 ± 0.04	0.17 ± 0.06	0.36± 0.02	0.07 ± 0.06	88.22 ± 0.02
98/0040	1.05 ± 0.04	0.53 ± 0.01	0.42± 0.06	0.05 ± 0.03	87.99 ± 0.04
TMS 30572	1.75 ± 0.02	0.77 ± 0.06	0.33± 0.02	0.03 ± 0.02	87.32 ± 0.56
99/2123	2.80 ± 0.10	0.42 ± 0.02	0.53± 0.02	0.08 ± 0.01	85.91 ± 0.01
92/0067	1.08 ± 0.02	0.77 ± 0.05	0.60± 0.02	0.04 ± 0.01	87.16 ± 0.01
97/0039	2.10 ± 0.01	0.52 ± 0.03	0.50± 0.03	0.06 ± 0.04	86.08 ± 0.03
95/0379	1.23 ± 0.03	0.47 ± 0.02	0.43± 0.02	0.04 ± 0.03	87.38 ± 0.03
92B/0061	1.23 ± 0.03	0.08 ± 0.01	0.48± 0.06	0.08 ± 0.03	76.89 ± 0.04
98/0581	1.26 ± 0.02	0.53 ± 0.03	0.02± 0.01	0.04 ± 0.01	76.89 ± 0.03
96/1569	2.10 ± 0.01	0.52 ± 0.01	0.29± 0.01	0.03 ± 0.02	84.81 ± 0.01

Means and standard deviation of triplicate determinations of moisture and dry matter content.

Table 4. Functional Properties of *fufu* flours processed from 43 CMD resistant varieties in Umudike

Cassava variety	WAC (g/ml)	BD (g/ml)
96/1569	1.20 ± 0.03	0.72 ± 0.01

TMS 30572	1.10 ± 0.03	0.67 ± 0.02
M98/0068	2.20 ± 0.10	0.72 ± 0.01
82/0058	1.10 ± 0.10	0.72 ± 0.04
98/0002	0.70 ± 0.20	0.63 ± 0.02
96/1632	0.70 ± 0.10	0.66 ± 0.01
97/0211	0.94 ± 0.15	0.66 ± 0.02
82/0058	1.00 ± 0.10	0.67 ± 0.04
4(2)1452	0.90 ± 0.02	0.71 ± 0.05
97/0162	1.10 ± 0.10	0.70 ± 0.02
99/3037	0.90 ± 0.30	0.67 ± 0.01
92B/00061	1.40 ± 0.30	0.72 ± 0.02
98/2226	1.00 ± 0.20	0.61 ± 0.01
92B/00068	2.20 ± 0.02	0.72 ± 0.02
91/0166	1.00 ± 0.10	0.67 ± 0.02
96/1642	1.07 ± 0.15	0.65 ± 0.01
98/0581	1.30 ± 0.10	0.67 ± 0.01
98/0505	1.20 ± 0.10	0.77 ± 0.01
97/2205	1.50 ± 0.02	0.63 ± 0.03
97/0039	1.30 ± 0.10	0.66 ± 0.04
96/0603	1.30 ± 0.20	0.66 ± 0.01
97/3200	1.20 ± 0.10	0.67 ± 0.01
96/1314	1.10 ± 0.10	0.63 ± 0.02
TME 419	1.20 ± 0.10	0.72 ± 0.01
99/3037	0.90 ± 0.30	0.67 ± 0.01
98/0510	0.90 ± 0.40	0.77 ± 0.03
92/0067	1.13 ± 0.06	0.63 ± 0.02
98/1565	1.07 ± 0.25	0.68 ± 0.02
97/4763	1.30 ± 0.01	0.66 ± 0.01
92B/00061	1.40 ± 0.30	0.72 ± 0.02
92/0057	0.90 ± 0.20	0.72 ± 0.01
95/0379	1.20 ± 0.10	0.77 ± 0.02
97/4769	1.10 ± 0.10	0.67 ± 0.02
95/0289	1.30 ± 0.03	0.77 ± 0.02
M98/0028	1.30 ± 0.20	0.62 ± 0.02
94/0561	1.30 ± 0.10	0.67 ± 0.02
92/0325	1.10 ± 0.10	0.67 ± 0.03
98/2101	1.20 ± 0.01	0.67 ± 0.01
98/0040	1.40 ± 0.10	0.67 ± 0.01
94/0026	1.30 ± 0.02	0.67 ± 0.02
92/0326	1.30 ± 0.20	0.72 ± 0.02
99/6012	1.50 ± 0.10	0.67 ± 0.02

Means and standard deviation of triplicate analysis.

Noting the minimum fat requirement of 6% in complementary formulation (Obatolu, 2002), none of the varieties in their flour form could meet this requirement. However, they met the Codex standard of FAO (1995) for cassava products. Generally variations in proximate composition could be attributed to processing and varietal differences. From the proximate values it is easy to single out variety 96/1632 as having the best nutritional value.

This confirms the carbohydrate as the main nutritional component of cassava roots with about 80% as starch (Purseglove, 1991). African countries are faced not only with problems of food security but also with nutritional insecurity which are contributing towards dietary micronutrient deficiencies. Fortunately cassava has been recognized as a suitable crop for micronutrient intervention in Africa (Oyewole and Asagbara, 2003).

Functional properties

The functional properties of the 43 CMD resistant varieties are reported in Table 4. Water absorption capacities (WAC) ranged from 0.70 to 2.20 g/ml. The CMD varieties 92B/00068 and M98/0068 had the highest WAC values. Water absorption capacity is a useful indication of whether protein can be incorporated with aqueous food formulations, especially those involving dough handling. Dough handling is an important processing operation in processed cheese, sausages and confectioneries. The interaction of proteins with water is important to properties such as hydration, swelling, solubility and gelation. It is a function of ionic strength, pH, temperature, size and shape of the protein molecules.

Gelatinization of carbohydrates and swelling of crude fiber may also occur during heating, leading to increased water absorption. Other processing factors that increase water absorption of flours include fermentation and germination. During fermentation, proteolytic activity takes place which causes increase in the number of polar groups. This development would increase hydrophilicity of the seed or flour proteins.

Bulk density (BD) ranged from 0.61 in the variety 98 / 2226 to 0.70 g/ml in varieties 98/0505, 98/0510, 95/0379 and 95/0289. Bulk density is the ratio of the mass per unit volume of a substance. It is an indication of the porosity of a product which influences package design. The bulk densities of the *fufu* flours will help us in determining suitable packaging requirements of the flours as it relates to the load the sample could carry if allowed to rest directly on one another.

Bulk density also relates to mouth feel and flavor of the food to which the flour is incorporated. Bulk density is affected by moisture and reflects particle size distribution of the flour.

Unlike the WAC, fermentation and germination are possible processing factors that cause decrease in bulk density. These factors which were employed as process methods in this work might have contributed greatly to the low BD values obtained.

Pasting properties

Table 5 shows the final viscosity, set back, peak time and

Table 5. Pasting properties of fufu flours processed from CMD resistant varieties in Umudike.

Cassava variety	Final-Viscosity (RVU)	Set-back(RVU)	Peak-time (min)	Pasting-Temp (°C)
96/1569	76.00	28.17	4.07	79.10
TMS 30572	104.75	29.75	4.07	79.15
M98/0068	102.83	34.75	4.07	77.55
82/0068	103.25	28.67	4.13	80.05
98/0002	133.25	37.00	4.20	79.15
96/1632	143.75	40.42	4.13	79.25
97/0211	154.25	41.5f	4.33	79.20
82/0058	154.83	37.83	4.27	78.40
4(2)1452	17125	48.25	4.33	79.15
97/0162	169.58	41.08	4.27	79.20
99/3037	183.92	54.33	4.27	79.20
92B/00061	187.08	55.92	4.13	79.15
98/2226	189.67	59.17	4.07	77.55
92B/00068	190.50	47.58	4.47	79.25
91/0166	191.50	43.83	4.40	79.15
96/1642	193.33	42.67	4.47	78.55
98/0581	193.33	47.75	4.47	80.85
98/0505	202.58	47.67	4.47	79.20
97/2205	202.67	54.25	4.40	78.50
97/0039	202.75	57.00	4.33	78.30
96/0603	204.58	50.50	4.47	79.15
97/3200	208.08	58.08	4.33	80.05
96/1314	210.25	58.33	4.27	78.45
TME 419	212.42	53.00	4.40	79.15
99/3037	220.25	51.33	4.47	79.20
98/0510	212.42	53.00	4.40	79.15
92/0067	221.00	56.67	4.67	80.10
98/1565	223.58	61.08	4.33	77.60
97/4763	226.67	55.92	4.33	77.75
92B/00061	228.00	61.42	4.40	79.95
92/0057	232.33	58.50	4.67	81.60
95/0379	233.83	59.00	4.87	80.05
97/4769	235.50	64.17	4.47	80.05
95/0289	239.42	61.92	4.67	78.45
M98/0028	245.17	61.00	4.73	79.9b
94/0561	245.50	53.00	4.53	78.35
97/0325	246.42	63.58	4.73	80.85
98/2101	249.50	61.25	4.80	79.15
98/0040	283.92	70.42	5.07	79.25
94/0026	286.58	64.42	4.93	78.45
92/0326	293.58	64.25	5.00	80.90

99/6012	295.00	62.08	5.33	80.05

Means of triplicate analysis.

Pasting temperatures of the flours of 43 CMD varieties. It is known that fufu flour is cooked into paste before consumption; hence, the pasting properties of fufu flour are an important quality index in predicting the behavior of fufu paste during and after cooking. Final viscosity is the most commonly used parameter to determine a particular relatively weak. The molecules are able to penetrate their starch granules much easier, and the granular swell enormously leading to weakening of associated forces which in turn makes them susceptible to breakdown. Breakdown is responsible for long cohesive nature of the cassava paste.

Set back viscosities showed variations in the fufu pastes ranging from 28.17 in the paste made from 96/1569 variety to 70.42 RVU in the 98/0040 variety. Setback value is the difference between final viscosity and hot paste viscosity or trough. It is a measure of the stability of the paste after cooking. It is the cooling phase of the mixture during pasting in which a re-association between the starch molecules occurs to a greater or lesser degree. It therefore affects retrogression or re-ordering of the starch molecules. Set back pasting property has been reported to correlate with texture of fufu flours. It is also associated with synergism and weeping (Sanni et al., 2006). Low set back of fufu paste indicates high stability. Hence, fufu paste obtained from CMD resistant varieties 96/1569 with setback value of 28.17 RVU will be most stable after cooking.

Peak time is the time at which the viscosity peaks. It measures the time it takes for the fufu pastes to gel during cooking. Peak time of the fufu paste obtained from CMD-resistant varieties ranged from 4.00 to 5.33 min, which was obtained at a temperature range of 77.55 to 81.60OC.

Starch-based sample quality. It gives an idea of the ability of a material to gel after cooking. Final viscosity of the fufu flours processed from 43 CMD resistant varieties ranged from 76.00 in 96/1569 to 295.00 RVU in the 99 / 6012 variety. Fufu flours with high viscosities showed that the associative forces between the starch molecules are:

Conclusion

The proximate composition of *fufu* flours processed from CMD resistant varieties in Umudike showed low moisture, high carbohydrate and high dry matter contents. These are indications of stable shelf life, cheap and available source of calories to the consumers most especially in the rural areas. It showed ease of reconstitution during preparation into *fufu* dough. Water absorption capacity of the *fufu* flours enables us to know the extent to which water is added during dough preparation and to improve handling characteristics and maintain freshness in the dough. Bulk densities of the *fufu* flours from the CMD resistant cultivars will guide the processors to determine the packaging requirement of the flours as it relates to the load the sample could carry if allowed to rest directly on one another.

Pasting properties will help the consumers to know the cassava varieties with ease of reconstitution and consistency of dough. Therefore, this work will help the farmers, consumers and industrialists to have idea on the CMD resistant varieties with desirable qualities for *fufu* production in Umudike location. Therefore, processing of cassava in various food forms like *fufu* flour has the potential to help Nigeria improve its food security, diversify its manufacturing base, generate more income, raise employment and achieve trade balance.

REFERENCES

Akingbala JO, Oguntimehin B, Abas AB (1991). Effects of processing methods on the quality and acceptability of *fufu* from low cyanide Cassava. J. Sci Food Agric. 5A (1): 151-154.

AOAC. (1990). Official Methods of Analysis 15th Ed. Association of Official Analytical Chemists , Washington D .C US A .

FAO (1995). Codex Standards for edible cassava Flour. Codex 176 – 1989 (Rev. 1 – 1995), Codex Legal Alimentarius 133 - 36, Canadian Legal Info. Institute. Vol. 7.

IITA (1990). Cassava in *Tropical Agric*: A Reference Manual. IITA, Ibadan, Nigeria, pp. 87-120 (1990).

IITA (2005). Cassava illustration guide book, growing cassava commercially in Nigeria. International Institute of Tropical Agriculture, Ibadan, Nigeria. pp. 21-22

Ngoddy PO (1989). Processing and storage of cassava. *Proc. of a course* held at University of Nigeria Nsukka, 10–23 April. 1988. Dotam Publications Ltd. pp.51-57.

Nwabueze TU, Odunsi FO(2007).Optimization of process conditions for cassava (*Manihot esculenta*) *lafun* production. Afr. J. Biotechnol. 6 (5) 603-611.

Nwabueze TU, Anoruoh GA (2008). Evaluation of Flour and Extruded Noodles from Eight Cassava Mosaic Disease (CMD) Resistant Varieties. http://fabt.edmgr.com/

Obatolu VA (2002). Nutrient and sensory qualities of extruded malted or unmalted millet / soybean mixture. Food Chem. 76:129-133

Okaka JC, Potter NN (1979). Tropical plant perishables: handling, storage and processing. Silicon Valley Publishers, Enugu.

Okezie BO, Bello AB (1988). Physico – chemical and functional properties of winged bean flour and isolate, compared with soy isolate. J. Food Sci. 53: 450-454.

Okpokiri AO, Ijeoma BC, Alozie SO, Ejiofor M.AN(1984). Production of improved Cassava *fufu.* Niger. Food J. 2:145-148.

Oyewole OB, Asagbara Y (2003). Improving traditional Cassava processing for nutritional enhancement. Food Nutr. Agric 32: 17-21.

Purseglove JW (1991). Tropical crops: Dicotyledons: Longman Scientific and Technical. Co-published in the United States with John Wiley and Sons. NewYork.

Sanni LO, MaziyaDixon B, Akanya CI, Alaya Y, Egwuonwu CV, Okechukwu RU, Ezedinma C, Akoroda M, Lemchi J, Ogbe F, Okoro E, Tarawali G, Mkumbira J, Patino M, Semakula G, Dixon A (2005). Standard for cassava products and guidelines for export. IITA, Ibadan, Nigeria, pp. 11-39.

Sanni LO, Adebowale AA, Filani TA, Oyewole OB, Westby A (2006). Quality of flash and rotary dried *fufu* flour. J. Food Agric. Environ. 4 (3& 4), July – October, 2006.

SAS (1999). Statistical Analytical System. Copyright version. SAS Institute Inc., Cary NC, USA.

Sefa-Dedeh S, Saalia FK (1997). Extrusion of maize – cowpea blends in a modified oil expeller. J. Sci. Food Agric 73: 160 -168.

Wheatley CC, Best R (1991). How can traditional forms of nutrition be maintained in urban centres: the case of cassava. Entwicklung Landlicher Raum. 25(1):13-16.