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The Physicochemical and Pasting Properties of High Quality Cassava Flour and Tiger Nut Composite Blends in Chin-chin Production

Eke- Ejiofor J*, **Allen J. E**

Department of Food Science and Technology, Rivers State University, Nkpolu Oroworukwo, P.M.B.5080, Port Harcourt, Nigeria
*Corresponding author: joyekee@yahoo.co.uk

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Abstract The study investigated the chemical, functional and pasting properties of composite blends of cassava and tiger nut residue flour as well as the proximate and sensory properties of chin-chin produced from the blends. Analysis was done using standard methods. Chin-chin was prepared from blends of high quality cassava flour (HQCF) and tiger nut residue flours and substituted at 10%, 20%, 30%, 40% and 50% levels. Moisture and ash content for composite flour increased from 11.17% to 15.26% and from 0.10 to 0.75% in sample A (100% HQCF) and E (60% HQCF flour: 40% TR flour) respectively. Sugar and amylose showed a significant ($p \leq 0.05$) increase as substitution of tiger nut residue flour increased while pasting properties of the composite flour were observed to decrease significantly ($p < 0.05$) except for the pasting time and temperature which increased with an increase in substitution of tiger nut residue flour. Functional properties showed a significant ($p \leq 0.05$) increase in oil and water absorption capacities, swelling power and least gelation concentration of composite blends with increase in the level of substitution of tiger nut residue flour. Results for chemical composition for chin-chin indicated that moisture, fat, protein and fibre contents increased with an increase in the level of tiger nut residue substitution while ash content, carbohydrate and energy in kcal/g decreased with an increase in the level of tiger nut residue flour inclusion. Sensory evaluation result of chin-chin gave acceptable products and showed that sample E with 40% tiger nut residue inclusion was the most preferred in terms of texture 6.75, flavor 7.30, taste 7.85, Crispness 6.80 and general acceptability 7.35. Therefore, the study showed that tiger nut residue flour can find useful application in confectioneries.

Keywords: *cassava, tiger nut, composite, physicochemical, pasting, chin-chin*

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1. Introduction

Cassava (*Manihot esculenta crantz*) is a major food crop in Nigeria supplying about 70% of the daily calorie of over 50million people in Nigeria [1]. It serves as the third most important food source in the tropics after cereal crops such as rice and maize. It constitutes 60% of the daily calorie needs of the population in tropical and Central America [2]. As a food crop, it fits well into the farming system of small holder farmers in Nigeria because it is available all year round, thus providing household food security [3]. Cassava plant gives the highest yield of carbohydrates and nutritionally cassava is a source of dietary energy for the low income consumers in many parts of tropical Africa including the major urban areas [4]. The crop is principally used as human food in the fresh, boiled, baked, fried, pounded and in numerous processed forms [5].

High Quality cassava flour (HQCF), produced from wholesome, freshly harvested and rapidly processed cassava has been identified as a local alternative to substitute part of wheat in composite flours [6] and can be used whole for confectioneries that does not require significant volume increase like bread. It is usually characterized as whitish or creamy, odourless, bland or sweet in taste and free from adulterant [7]. Tiger nut (*Cyperus esculentus lativum*) is an underutilized tuber of family cyperaceae. The nuts are valued for their highly nutritious starch content, dietary fiber and digestible carbohydrate [8]. It has been reported to be high in mineral, oleic acid, moderate protein, vitamin C and E contents [9]. Tiger nuts are often eaten raw, dried, roasted or grated and used as flour [10].

The advantages of cassava as food security crop in sub-Saharan Africa usually outweigh the nutritional drawbacks that sometimes make cassava appear an inferior food [11]. This necessitates the need for improvement with tiger nut residue. This will diversify usage and improve the nutritional quality of the product, as well as provide more dietary fiber. An improvement on the quality of HQCF would add value to subsequent product development.

Research has shown that HQCF has significantly low contents of ash, fat, fibre and protein. Tiger nut residue flour therefore is an important source of fibre that is discarded as waste and therefore can be substituted with high quality cassava flour in order to improve the nutritional properties thereby making good advantage of the tiger nut residue. Therefore, the study is aimed at evaluating the chemical, functional, sensory and pasting properties of high quality cassava flour (HQCF) and tiger nut residue composite flour blends.

2. Materials and Methods

2.1. Materials

2.1.1. Collection of Materials

Improved Cassava roots (TME419) were obtained from Ego Farms in Rukpoku, Obio Akpo Local Government Area of Rivers State while Tiger nuts (*Cyperus esculentus*) yellow variety was purchased from mile 3 market in Port Harcourt. Other ingredients such as butter, sugar, fresh eggs, salt, milk, flavor and sodium bicarbonate (baking powder) used for product development were purchased from Mile 1 market in Diobu, Port Harcourt. Rivers State, Nigeria.

2.1.2. Chemicals

Chemical used for the analysis were obtained from the Biochemistry Laboratory, Department of Food Science and Technology, Rivers State University, Nkpolu- Oroworukwo Port Harcourt. All chemicals used for this study were of analytical grade.

2.2. Methods

2.2.1. Processing of High Quality Cassava Flour (HQCF)

Cassava roots (TME419) were processed into High Quality cassava flour using the method described by IITA [12].

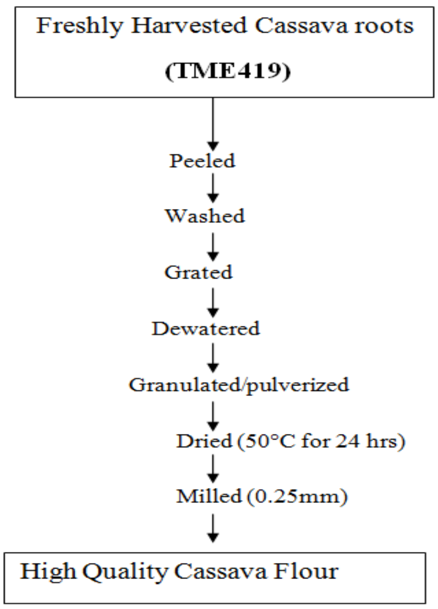

Figure 1. Flow chart for HQCF Production (Source: [12])

2.2.2. Preparation of Tiger nut Residue Flour

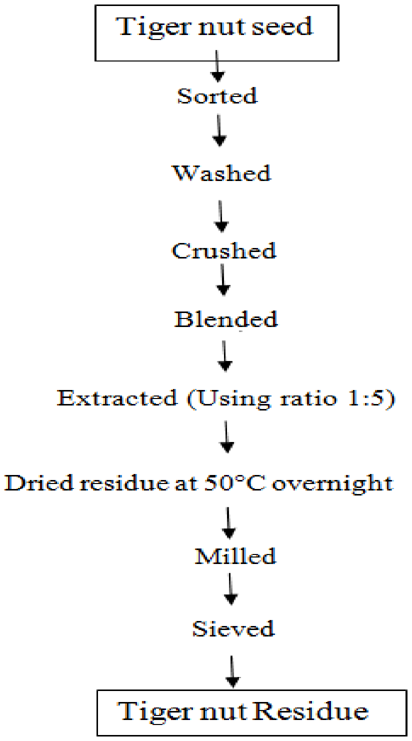

Figure 2. Flow chart illustrating the production of tiger nut residue flour (Source: [13])

2.2.3. High quality Cassava flour/Tiger Nut Residue Composite Flour

Seven blends of tiger nut residue flour were mixed with varying proportions of high quality cassava flour. Flour ratios of 5%, 10%, 15%, 20%, 25% and 30% used in baking.

Table 1. Formulations of Flour blends

Flour Sample	Tiger nut residue (%)	High Quality Cassava Flour (HQCF) (%)
A	-	100
B	10	90
C	20	80
D	30	70
E	40	60
F	50	50

2.2.4. Preparation of Chin-chin

Table 2. Table of Recipe for Chin-chin preparation

INGREDIENT	AMOUNT
Flour	200g
Sugar	50g
Margarine	20g
Baking powder	5g
Eggs	90g
Nut meg	1g
Water	125ml
Vegetable oil for frying	750ml

Source: [14].

The composite flour, sugar, butter, egg, baking powder, water, and milk were mixed together at appropriate quantities in a bowl. The dough was placed on a work surface and kneaded until smooth and elastic. The kneaded dough was rolled out to approximately 2cm thickness and then cut into small squares (2cm by 2cm size). Dough was fried using a deep fryer at about 180°C for about 8minutes until golden brown. The fried chin-chin was removed and drained of excess oil before serving [15].

2.3. Sensory Evaluation

The sensory attributes of the chin-chin was obtained by using simple hedonic tests as described by Larmond [16]. This was done using a 20-member panel comprising of students of the department of Food Science and Technology, who were familiar with wheat based chin-chin and were neither sick nor allergic to any raw material used for the development of the product. A 9-point hedonic scale was used where 1 and 9 represented dislike extremely and like extremely respectively. The attributes that were evaluated include color, taste, flavor, texture, crispness and general acceptability. Mean scores were analyzed statistically using analysis of variance and least significant difference test [17].

2.4. Proximate Analysis

The moisture, ash, fat, protein and crude fiber content were determined according to a procedure described by [18]. Carbohydrate was determined by the calculation

2.4.1. Energy determination

The energy content (E) of the value added products chin-chin was calculated using Atwater factor as described by Obiegbuna and Baba, [19].

2.4.2. Functional Properties

Bulk density, least gelation concentration (LCG), dispersibility, oil absorption, water absorption capacity (WAC) was determined by the method as described by Elkhalifa *et al*. [20], Dispersibility and Swelling Power was determined by the method as described by [21]. Least Gelation Concentration Capacity was by the methods of Sathe and Salunkhe [22].

Determination of pasting properties: Pasting properties was determined with the Rapid Visco Analyser (RVA) as described by Sanni *et al*. [23].

2.5. Statistical Analysis

Analysis was carried out in duplicate. All values obtained were subjected to analysis of variance (ANOVA) using Microsoft excel spreadsheet and the differences in mean significant using LSD test which was defined at ($p<0.05$).

3. Results

3.1. Chemical Composition of High Quality Cassava/Tiger Nut Residue Composite Flour Blend

Table 3 and Table 4 shows the chemical composition of high quality cassava flour/tiger nut residue composite flour and chin-chin produced from the blends. Moisture content of the flour ranged from 11.70-15.26% with sample E (60% HQCF: 40%TRF) recording highest and sample A (100% HQCF) the lowest, while moisture content of chin-chin ranged from 8.35 - 12.85%. Moisture content of sample A (100% HQCF) was significantly different ($p<0.05$) from all the samples for both flour and chin-chin samples as both increased in moisture as the level of substitution increased. The moisture content estimates directly the water content and indirectly the dry matter of the samples. High-moisture products (>12%) usually have shorter shelf stability compared with lower-moisture products (<12%), as reported by Ashworth and Draper [24]. Therefore, the low moisture content of all the flour blends and chin-chin (except for substitution of tiger nut residue up to 50% and 100% tiger nut residue) makes them less liable to microbial attack. This result correlates with the findings of Adeoti *et al* [25] who reported an increased moisture content of tapioca as the enrichment with tiger nut flour increased. Moisture content of wheat/tiger nut (raw and dry residue) cake increased as substitution of tiger nut residue increased [26]. This could be due to the high moisture content (11.8%) of tiger nut residue [27]. There was a significant ($p<0.05$) increase in the moisture content of the chin-chin and flour blends as substitution of tiger nut increased.

Table 3. Chemical composition (%) result of High Quality Cassava/Tiger Nut Residue Composite Flour Blend

Samples	MC	Ash	Fat	Crude Protein	Crude Fiber	TAC	Sugar	Starch	Amylose	A/pectin	Energy (kg/cal)
A	11.70^{d}	0.10^{e}	7.0^{bc}	2.28^{b}	3.56^{e}	75.30^{a}	2.88^{c}	79.80^{a}	28.86^{b}	50.94^{a}	333.03^{e}
B	13.80^{c}	0.10^{e}	6.5^{d}	2.71^{ab}	3.07^{e}	73.82^{a}	2.59^{d}	79.16^{a}	29.65^{a}	49.51^{b}	330.07^{e}
C	14.65^{a}	0.50^{d}	8.5^{ab}	3.15^{a}	7.47^{d}	65.71^{b}	3.04^{b}	71.98^{d}	27.95^{c}	44.03^{d}	347.40^{cd}
D	13.00^{b}	0.70^{c}	9.8^{a}	3.15^{a}	10.20^{b}	63.04^{c}	4.05^{a}	73.08^{c}	29.80^{a}	43.28^{d}	339.43^{de}
E	15.25^{a}	0.75^{b}	9.6^{a}	3.15^{a}	8.70^{c}	60.99^{d}	4.16^{a}	77.42^{b}	26.22^{d}	51.20^{a}	354.79^{bc}
F	13.50^{bc}	0.85^{a}	7.2^{bc}	3.15^{ab}	18.66^{a}	58.44^{e}	4.16^{a}	76.58^{b}	28.35^{c}	48.23^{c}	358.99^{b}
LSD	0.75	0.09	1.5	0.65	0.67	1.98	0.13	0.06	0.17	0.17	356.12^{bc}
											370.69^{a}

Means with same superscripts in the same column are not significantly differently DMRT ($p \geq 0.05$)

KEYS: A= 100% HQCF, B= 90% HQCF: 10% tiger nut residue, C= 80% HQCF: 20% tiger nut residue, D= 80% HQCF: 30% tiger nut residue, E= 60% HQCF: 40% tiger nut residue, F = 50% HQCF: 50% tiger nut residue, MC= Moisture Content, TAC= Total Available Carbohydrate, A/pectin= Amylopectin

Table 4. Proximate composition of chin-chin produced from High Quality Cassava Flour/Tiger nut residue composite flour Blend

Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Crude Fiber (%)	CHO (%)	Energy (Kcal)
A	8.59±0.35[b]	1.09±0.00[a]	24.74±0.19[a]	20.98±0.51[d]	12.05±0.00[b]	32.79±0.34[a]	338.55±0.61[a]
B	12.10±0.00[a]	0.70±0.00[b]	26.75±0.65[ab]	22.40±0.42[d]	11.08±0.82[c]	26.98±0.26[b]	314.61±5.81[b]
C	9.40±0.28[b]	0.80±0.14[b]	27.00±1.89[a]	24.69±0.71[c]	11.46±0.49[bc]	26.66±2.53[b]	317.72±6.95[b]
D	12.40±0.28[a]	0.40±0.07[c]	27.12±0.03[a]	27.30±0.10[b]	12.31±0.21[ab]	20.42±0.12[c]	300.96±2.32[c]
E	12.85±0.07[a]	0.40±0.00[c]	28.40±0.57[a]	24.15±1.54[c]	12.61±0.48[ab]	21.59±0.42[c]	313.43±8.27[b]
F	12.40±0.14[a]	0.80±0.00[b]	27.42±0.94[a]	32.00±0.00[a]	12.95±0.36[a]	14.44±0.45[c]	283.95±1.20[d]
LSD	0.64	0.18	2.18	1.42	0.72	2.34	8.21

Means with different superscript in the same column are significant different (p<0.05)
Key: A=100% HQCF, B=90% HQCF: 10% tiger nut residue, C=80% HQCF: 20% tiger nut residue, D=70% HQCF: 30% tiger nut residue, E=60% HQCF: 40% tiger nut residue, F=50% HQCF: 50% tiger nut residue.

Ash content of the flour blends ranged from 0.10-0.85% with sample F (80% HQCF: 50%TRF) recording the highest against samples A and B recording the lowest, while ash content of chin-chin decreased from 1.09 – 0.40% with increase in the level of substitution, but an increase was observed for the HQCF/Tiger nut residue flour blends. This decrease in ash content of the chin-chin could be due to the processing operations of the product at high temperature. The result obtained in this study were similar to the decrease in the ash content of biscuits with corresponding increase in the proportion of tiger nut flour in acha flour [28]. The increase in ash content of the flour blends were also in agreement with the work of Adegunwa *et al* [29] who reported ash content of 1.33-2-00% for plantain-tiger nut composite flour. The maximum ash content of the tiger nut residue flour (0.85%) in the present study was higher than the value of 0.5% reported by Wayah and Shehu [27]. This result shows that tiger nut residue flour increased the ash content of high quality cassava flour, indicating that the flour blends were likely to be good sources of mineral elements. The ash content of 100% HQCF (0.10%) was lower than the value of 0.71% reported for HQCF by Maziya-Dixon *et al*. [30] and this may be due to the type of variety of cassava used in this study.

Fat content of the flour blends ranged from 6.5-9.8% with samples D (70% HQCF: 30%TRF) as the highest and B (90% HQCF: 10%TR) as lowest, with a corresponding increase in the fat content of the chin-chin from 24.74-28.40% as the substitution with tiger nut residue flour increased. The high fat content of the chin-chin is attributable to the fat from the frying oil. The result of the present study is in agreement with the findings of Eke-Ejiofor and Deedam, [26] who reported that fat content increased with an increase in the level of substitution of tiger nut residue in wheat-tiger nut residue cookies from 24.89% - 29.26%.

Protein content of the flour samples ranged from 2.28-3.15% with samples C, D, E and F having higher values of protein while sample A (100% HQCF) recorded the lowest. Protein content of the chin-chin ranged from 20.98 – 32.00%. There was an increase in the protein content of the flour blends as well as the chin-chin, as the level of tiger nut residue increased. Sample A (100% HQCF) was not significantly different from sample B which had 10% inclusion, while samples C-F showed no significant (p<0.05) differences with tiger inclusion. Chin-chin made with sample A was significantly different (p<0.05) from the other samples. The increase in the protein content of the chin-chin and HQCF/tiger nut residue flour blends can be attributed to tiger nut residue inclusion in the blends and other ingredient like egg added in the preparation of the chin-chin dough. Adegunwa *et al* [29] also observed an increase in protein content as tiger nut flour substitution increased in composite plantain flour. The protein content of the tiger nut residue in this study (2.28 - 3.15%) is higher than the findings of Wayah and Shehu [27] with a value of 1.5%. This could be due to the varieties and methods of processing of the tiger nut residue. Similarly, the 100% HQCF (2.28%) was within the range of values (1.17–3.48%) reported for newly released varieties of cassava by Emmanuel *et al*. [31].

Crude fiber content of the flour ranged from 3.07-18.66% with samples F (50%HQCF: 50%TNRF) as highest and B (90% HQCF: 10% TNRF) as lowest, while the fiber content of chin-chin ranged from 11.08-12.93%. There was a significant (p<0.05) increase in the crude fiber of the flour blends and chin-chin samples as substitution with tiger nut residue increased. Crude fiber content of the flour samples for samples C, D E and F were significantly (p<0.05) higher than sample A (100% HQCF). The increase in the crude fiber of the flour blends and chin-chin samples can be attributed to the high fiber content of tiger nut residue. This increase was also observed by Eke-Ejiofor and Deedam [26] who reported an increase in the fiber content (1.08-3.15%) of cakes produced from wheat-tiger nut residue composite flour. The level of crude fiber obtained in 100% HQCF (3.56%) is close to the values (3.99–6.68) reported in chin-chin regardless of the proportions. Nutritional claims for dietary fiber foods [32] recommended that for a product to be labeled as “source of fiber”, it must contain >3g dietary fiber/100g food. Since the HQCF/tiger nut residue composite flours obtained in this study all contain more than 3g dietary fiber/100g, it implies that the HQCF/TNRF blends can be regarded as “source of dietary fiber.

Carbohydrate content of the HQCF/TNRF blends ranged from 58.44-75.35% with samples F as lowest and A having higher, while carbohydrate of chin-chin ranged from 32.49-14.44% showing a decrease with increasing level of tiger nut residue flour substitution. This was similar to the findings of Adegunwa *et al* [29] who reported a decrease (78.48 - 46.07%) in the carbohydrate content of plantain-tiger nut flour blends as tiger nut flour substitution increased. This could be attributed to the low carbohydrate content of tiger nut residue flour (43.0%) to high quality cassava flour as reported by Wayah and Shehu [27]. This decrease was also reported by Kareem *et al*. [33] for high quality cassava-tiger nut residue composite flour from 83.91-57.48% as substitution levels of tiger nut flour increased.

Sugar content ranged from 2.59-4.16% with samples E and F recording the highest and B the lowest. Sugar content increased as the level of substitution of tiger nut residue increased. This is attributed to the high sugar content in the raw tiger nut which is higher than that of cassava flour (0.96%) as reported by FAO [34] and TISSL [10].

Starch content of the flour blends ranged from 71.98-79.80% with sample A recording the highest while sample C lowest. Starch content decreased as the substitution of tiger nut residue flour increased. This can be attributed to tiger nut residue inclusion in the blends, as the inclusion reduced the available starch.

Amylose is one of the two components of starch, which is more soluble in water than the other component amylopectin. Amylose content of the flour samples ranged from 26.22-29.80% with sample D recording highest and sample E as lowest. The inclusion of different levels of tiger nut residue affected the amylose content positively. The higher the amylose content of a starch based material, the less expansion potential and the lower the gel strength for the same starch concentration. While, amylopectin content of the flour samples ranged from 43.28-51.20% with samples E as the highest and D as lowest, showing a reduction as the level of tiger nut residue increased.

Energy content of the product chin-chin reduced from 338.55 - 283.95Kcal/g with samples A recording the highest energy and F the lowest. Research has shown that energy content is affected by the proportion of fat, protein and carbohydrate in a given food product, therefore the energy content of the chin-chin 338.55-283.95kcal/g decreased as the substitution of tiger nut residue flour increased.

3.2. Functional Properties of High Quality Cassava Flour/Tiger nut Residue Composite Flour Blend

Functional characteristics are required to evaluate and possibly help to predict how proteins, fat, fibre and carbohydrates may behave in a specific system [35].

Table 5 shows the functional properties of HQCF/tiger nut residue composite flour blend. Oil absorption capacity ranged from 1.470-2.340g/ml with sample C recording highest and sample E lowest. There was an increase in the oil absorption capacity of the flour blends from 1.470-2.340g/ml however, there was no significant ($p<0.05$) difference observed. The ability of the proteins of these flours to bind with oil makes it useful in food system where optimum oil absorption is desired. The substitution of tiger nut residue increased the oil absorption capacity of the blends up to 40% inclusion. These results agreed with the findings of Ayo *at al* [28] who reported that adding tiger nut flour into acha, increased the oil absorption capacity of acha based biscuits. The increase in the oil absorption capacity could improve flavor retention in HQCF-tiger nut residue composite products. The oil absorption capacity of 100% HQCF (0.84g/ml) in this study was in agreement with the value of 0.84g/ml reported for HQCF by Iwe *et al*. [36].

Water absorption of the flour ranged from 1.490-1.810g/ml with sample E recording the highest and sample D lowest. Water absorption capacity increased as the level of substitution of tiger nut residue flour increased from 1.490-1.810g/ml. Higher water absorption was recorded for sample E while the results showed no significant difference ($p<0.05$) among the samples. Water absorption capacity represents the ability of a product to associate with water under conditions where water is limited [37]. The increase in water absorption of the flour blends could be attributed to the presence of high amount of carbohydrates (starch) in the HQCF and fiber content in the tiger nut residue flour and this could be as a result of the hydrophobic nature of carbohydrate and fiber. This is in agreement with the findings of Ayo *et al* [28] who reported an increase (0.98-1.05%) in the water absorption capacity of acha cookies as tiger nut flour substitution level increased. The water absorption capacity of 100% HQCF (1.52g/ml) in this study was lower than the value of 2.1g/ml reported for HQCF by Iwe *et al*. [36] and this may be due to varietal differences.

Swelling power ranged from 1614-1828g/g with sample D recording highest and F the lowest. Swelling power increased as the substitution with tiger nut residue increased from 1738-1828g/g. Sample D (50% Tiger nut residue substitution) have the highest swelling power (1828g/g). Swelling power connotes the expansion accompanying spontaneous uptake of solvent [38]. Kinsella [39] reported that swelling causes changes in hydrodynamic properties of a food thus impacting characteristic such as body, thickening and increase viscosity to foods. Swelling index is the amount of water soluble solids per unit weight of the sample. It is an index of protein functionality such as denaturation and its potential applications. The higher the solubility, the higher the functionality of the protein in a food [40]. The higher swelling power of flours compared to others indicates that the protein component of the samples are still intact.

Table 5. Functional properties of High Quality Cassava Flour/ Tiger nut residue composite flour Blend.

Sample	Oil absorption (g/ml)	Water absorption (g/ml)	Swelling power (g/g)	Dispersibility(%)	Bulk density (g/ml)	Least Gelation Concentration (%)
A	$1.84{\pm}0.03^{ab}$	$1.49{\pm}0.18^{a}$	$1738{\pm}0.00^{e}$	$68.80{\pm}0.00^{a}$	$0.71{\pm}0.00^{a}$	$2.00{\pm}0.00^{b}$
B	$1.79{\pm}0.37^{ab}$	$1.52{\pm}0.21^{a}$	$1768{\pm}0.00^{d}$	$52.00{\pm}0.00^{f}$	$0.59{\pm}0.00^{b}$	$2.00{\pm}0.00^{b}$
C	$2.34{\pm}0.05^{a}$	$1.60{\pm}0.09^{a}$	$1799{\pm}0.00^{b}$	$57.00{\pm}0.00^{e}$	$0.53{\pm}0.00^{d}$	$4.00{\pm}0.00^{a}$
D	$1.97{\pm}0.19^{ab}$	$1.66{\pm}0.39^{a}$	$1828{\pm}0.00^{a}$	$58.00{\pm}0.00^{d}$	$0.51{\pm}0.00^{e}$	$4.00{\pm}0.00^{a}$
E	$1.47{\pm}0.42^{b}$	$1.81{\pm}0.26^{a}$	$1786{\pm}0.00^{c}$	$59.00{\pm}0.00^{c}$	$0.50{\pm}0.00^{f}$	$4.00{\pm}0.00^{a}$
F	$1.84{\pm}0.40^{ab}$	$1.80{\pm}0.19^{a}$	$1614{\pm}0.00^{f}$	$63.00{\pm}0.00^{b}$	$0.54{\pm}0.00^{e}$	$4.00{\pm}0.00^{a}$
LSD	0.55	0.66	0.00	0.00	0.00	0.00

Means with different superscript in the same column are significant different ($p<0.05$)

Key: A=100% HQCF, B=90% HQCF: 10% tiger nut residue, C=80% HQCF: 20% tiger nut residue, D=80% HQCF: 30% tiger nut residue, E=60% HQCF: 40% tiger nut residue, F =50% HQCF: 50% tiger nut residue

Dispersibility of the flour ranged from 52.00-68.00% with samples A as highest and B lowest. There is also a significant ($p<0.05$) decrease in the dispersibility of the flour from 68.80-52.00% as the substitution of tiger nut residue flour increased. Sample A (100% HQCF) had the highest Dispersibility (68.80%) and this was significantly ($p<0.05$) different from the other flour blends. Dispersibility determines the tendency for flour to more apart from water molecules and reveals its hydrophobic action. Kulkani *et al*. [21] reported that the higher the dispersibility, the better the starch reconstitutes in water to give a fine and consistent paste.

Bulk density ranged from 0.504-0.710g/ml with samples A recording highest and E recording lowest. There was a significant ($p<0.05$) decrease in the bulk density of the flour blends from 0.71-0.50g/g as substitution with tiger nut residue flour increased. Bulk density is desirable for it great ease at dispersibility and reduction of paste thickness. The low bulk density of the flour blends in relation to the control (sample A) could be an advantage in the formulation of complementary foods [41]. The lower bulk density of the flour blends also implies less quantity of the food sample in terms of volume during packaging. The bulk density of 100% HQCF is in agreement with the report of Iwe *et al*. [36].

Least gelation concentration of the flour samples ranged from 2-4% with samples C, D, E and F as highest (4%) and samples A and B as lowest (2%). The least gelation concentration increased as the substitution level of tiger nut residue flour increased from 2-4%. The least gelation concentration can be described as a measure of the minimum amount of starch needed to form a gel in a given volume of water [42].

3.3. Pasting Properties of High Quality Cassava Flour/Tiger Nut Residue Composite Flour Blend

Table 6 shows the pasting properties of HQCF/Tiger nut residue flour blends such as peak, trough, breakdown, final viscosity, set back viscosity, pasting time and pasting temperature. The pasting property is one of the most important properties that influence quality and aesthetic consideration in the food industry since they affect texture and digestibility as well as the end use of starch based food commodities [43].

Peak viscosity ranged from 743.13-181.84RVU with sample A (100% HQCF) recording the highest and sample F (50% HQCF: 50%TRF) the lowest value. There was a significant ($p<0.05$) decrease in the peak viscosity of the flour blends as substitution of tiger nut residue flour increased from 743.13-181.84RVU. Sample A (100% HQCF) recorded the highest (743.13RVU) while Sample F (50% tiger nut residue flour substitution) had the lowest. Peak viscosity is an index of the ability of starch-based food to swell freely before their physical breakdown [40,44]. High peak viscosity indicates high starch content and this could explain why 100% High quality cassava flour had highest peak viscosity. The present study agrees with the observation of Kehinde *et al*., [45] who reported a decrease in the peak viscosity of wheat-tiger nut pomace flour blends (136-113RVU) as substitution with tiger nut pomace increased. Adegunwa *et al* [29] reported a decrease in the peak viscosity (12.30-509.09 RVU) of plantain-tiger nut composite flour as substitution with tiger nut flour increased. The relatively low peak viscosity effect by tiger nut residue flour addition is an indication that the flour can be used for the production of products that require low gel strength and elasticity [46].

Trough viscosity of the flour blends ranged from 248.38-78.58RVU with sample A having the highest and sample F the lowest. Trough is the minimum viscosity value in the constant temperature phase of the pasting profile and it measures the ability of the paste to withstand breakdown during cooling [47]. This property also decreased significantly ($p<0.05$) with increase in tiger nut residue substitution from 248.38 – 78.58RVU. This is similar to the findings of Kehinde *et al*., [45] who reported a decrease in the trough viscosity of wheat-tiger nut pomace flour blends (90.2-75.7RVU) as substitution with tiger nut pomace increased. This trend was also reported by Ayo *et al* [28] who observed a decrease in trough viscosity of Acha based biscuits (1050.33-803.33RVU) as substitution with tiger nut flour increased. The decrease in the peak and trough viscosity could be due to the increase in fiber content as carbohydrate level decreased with substitution of tiger nut residue flour.

Break down viscosity decreased from 494.75- 96.17RVU with sample A (control) recording the highest and E the lowest. Break down viscosity measures the ability of paste to withstand breakdown during cooling. The decrease in the break down viscosity values could be attributed to the relative increase in fiber content which had the ability to decrease the stability of the food system during processing and storage. High values indicate little breakdown of sample starches [29]. The statement of Adegunwa *et al* [29] applied to the present study as it was observed that the flour blends with less value broke down their starch components more. This feature was also evident in the product chin-chin, as samples with higher tiger nut residue had less adhesion. Kehinde *et al*., [45] also reported a decrease in the breakdown viscosity of wheat-tiger nut pomace flour blends (45.8-36.0RVU) as substitution with tiger nut pomace increased.

Final viscosity ranged from 364.92-116.21 RVU. The final viscosity of the flour samples decreased significantly ($p<0.05$) with an increase in tiger nut residue flour from 364.92-116.21RVU and this could be due to the relatively high fiber value of the added tiger nut residue flour with subsequent negative effect on the quality of starch. This results correlates with the findings of Ayo *et al*, [28] who observed an increase in the final viscosity of Acha based cookies as level of substitution of tiger nut flour increased. Kehinde *et* al. [45] also reported a decrease in the final viscosity of wheat-tiger nut pomace flour blends from 170-183.7RVU as tiger nut pomace substitution increased. The decrease in the final viscosity might be due to the sample kinetic effect of cooling on viscosity and the re-association of starch molecules in the samples [48]. Final viscosity indicates the ability of the flour to form a gel or viscous paste after cooking and cooling [46].

Set back viscosity ranged from 116.54-37.63RVU, showing a significant ($p<0.05$) decreased as substitution with tiger nut residue increased from. Higher set back values are synonymous with reduced dough digestibility [22] while lower set back viscosities during the cooling of the paste indicate a lower tendency for retrogradation [49]. High setback is also associated with syneresis, therefore viscosity in sample A (100% HQCF) is an indication of greater tendencies towards retrogradation compared to other samples with low setback viscosities. This trend was also similar with the findings of Adegunwa *et al*, [29] who reported 0.63 - 196.59 RVU for plantain-tiger nut composite flour as substitution with tiger nut flour increased. Kehinde *et al*. [40] also reported a decrease in the setback viscosity of wheat-tiger nut pomace flour blends as substitution with tiger nut pomace increased from 93.6-91.0-RVU.

Pasting time ranged from 3.84-4.40min with samples D, E and F recording the highest values and A the lowest. Pasting time is a measure of the cooking time [46]. The pasting time of the flour blends increased significantly as substitution of tiger nut residue flour increased from 3.84-4.40min. This is expected as the presence of additional fiber changed the starch structure and behavior under gelling conditions. Adegunwa *et al* [29] reported an increase in the pasting time (4.83-7.23min) of composite flour comprising tiger nut flour and plantain flour as substitution of tiger nut flour increased.

Pasting temperature ranged from 73.58-77.45°C with sample C (70% HQCF: 20%TRF) recording the highest value and A the lowest. The pasting temperature is an indication of the gelatinization time during processing. It is the temperature at which the first detectable increase in viscosity is noted [50]. The results of the pasting temperature in the present study increased as the substitution of tiger nut residue flour increased from 75.58-77.45°C. This is expected as the pasting time has a direct relationship with the pasting temperature. This study is agreement with Adegunwa *et al* [29] who reported the pasting temperature (82-38-83.33°C) for composite flour comprising tiger nut flour and plantain flour as the level of tiger nut flour substitution increased. Kehinde *et al*. [45] also reported this increase for wheat-tiger nut pomace flour blends (88.4-90.0RVU) as substitution of tiger nut pomace flour increased.

3.4. Sensory Evaluation Result for Chin-Chin Produced From HQCF/Tiger Nut Residue Flour

Table 7 shows the mean sensory scores of chin-chin produced from HQCF/Tiger nut residue flour. Results showed that there was significant difference (p≤0.05) in all the sensory parameters evaluated. Color/appearance of the chin-chin decreased from 8.10- 5.58 with sample A (100% HQCF) as most referred and sample D (70% HQCF: 30%TRF) as least preferred. The color of the chin-chin shows that substitution level at 10% of tiger nut residue improved the color of the product compared to the control sample with high acceptability. The decrease in the color of the product may be attributed to the brown color of tiger nut residue flour, while texture for the chin-chin decreased with substitution of tiger nut residue flour from 8.10- 6.75 with samples A as most preferred while sample F least preferred. Texture also decreased with inclusion of tiger nut residue taste, flavor and crispness of chin-chin increased with substitution of tiger nut residue flour from 6.40-7.85, 6.15-7.30 and 4.65-6-80 respectively. The chin-chin produced from the flour blends compared favorably with 100% cassava flour which was the control. Overall acceptability of the chin-chin ranged from 5.25-5.91 with all the samples rated above average.

Table 6. Pasting Properties (RVU) of High Quality Cassava Flour/Tiger nut Residue Composite Flour Blend

Samp	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback (RVU)	Pasting time (min)	Pasting temp (°C)
A	743.13±17.39^{a}	248.38±4.66^{a}	494.75±22.03^{a}	364.92±15.56^{a}	116.54±10.9^{a}	3.84±0.05^{c}	73.58±0.04^{a}
B	300.13±2.83b	163.79±5.60^{b}	137.13±2.76^{bc}	223.46±1.94^{b}	59.67±7.54^{b}	4.24±0.05^{b}	76.63±0.04^{ab}
C	264.67±13.31^{c}	139.46±9.37^{c}	125.21±3.95^{c}	196.59±4.83^{c}	57.13±4.53^{b}	4.37±0.05^{b}	77.45±1.31^{a}
D	222.09±0.47^{d}	115.63±1.35^{d}	106.46±7.82^{cd}	171.13±0.42^{d}	55.50±1.77^{b}	4.40±0.00^{a}	76.33±0.60^{ab}
E	202.63±1.83^{b}	106.46±0.18^{d}	96.17±1.65^{c}	158.92±0.00^{d}	52.46±0.18^{b}	4.40±0.10^{a}	76.30±0.49^{ab}
F	181.84±3.66^{e}	78.58±0.71^{e}	103.25±2.94^{cd}	116.21±2.18^{e}	37.63±1.48^{b}	4.40±0.00^{a}	75.15±1.06^{bc}
LSD	21.88	13.75	22.73	18.75	15.89	0.13	1.72

Means with different superscript in the same column are significantly different (p<0.05)
Key: A=100% HQCF, B=90% HQCF: 10% tiger nut residue, C=80% HQCF: 20% tiger nut residue, D=80% HQCF: 30% tiger nut residue, E=60% HQCF: 40% tiger nut residue, F=50% HQCF: 50% tiger nut residue.

Table 7. Mean Sensory Scores of chin-chin produced from HQCF/ Tiger nut residue composite flour

Sample	Color	Texture	Taste	Flavor	Crispiness	Overall acceptability
A	8.10^{d}	8.10^{a}	7.05^{ab}	6.90^{ab}	5.30^{bc}	5.91^{a}
B	7.70^{ab}	7.80^{ab}	6.40^{b}	6.15^{b}	4.65^{c}	5.45^{ab}
C	6.85^{b}	7.50^{abc}	6.65^{b}	6.70^{ab}	5.45^{bc}	5.53^{ab}
D	5.85^{b}	7.10^{bc}	6.50^{b}	6.50^{ab}	5.40^{bc}	5.23^{b}
E	6.45^{c}	7.25^{abc}	7.30^{ab}	7.20^{a}	6.80^{a}	5.83^{a}
F	6.20^{b}	6.75^{c}	7.85^{a}	7.30^{a}	6.25^{ab}	5.73^{a}
LSD	0.99	0.81	0.93	0.86	1.07	0.50

Means with different superscript in the same column are significant different (p<0.05)
Key: A=100% HQCF, B=90% HQCF: 10% tiger nut residue, C=80% HQCF: 20% tiger nut residue, D=80% HQCF: 30% tiger nut residue, E=60% HQCF: 40% tiger nut residue, F =50% HQCF: 50% tiger nut residue.

4. Conclusion

The present study revealed that protein, ash, fat and fiber content of the cassava based chin-chin were enhanced; with a decrease in the pasting properties of the flour except for pasting time and temperature which did not adversely affect the physical appearance of the product. Blending of HQCF with tiger nut residue had significant increase on the functional properties of the flour blends. The significant increase in the fiber content could be nutritionally advantageous to consumers with the increase in the usage of HQCF to reduce the dependence on wheat. Tiger nut residue flour can be incorporated into HQCF up to 50% level without affecting the sensory parameters except color of the product.

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