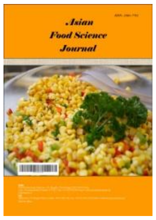

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Effects of Fermented Maize Residue Addition on the Physico-chemical and Sensory Properties of Chin-Chin

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Chin-Chin, a traditional Nigerian snack was prepared utilizing wheat-fermented maize residue composite flour at 0 – 30% replacement levels. Effects of this addition on the functional and pasting properties of the flour composite was evaluated. The snack produced was also evaluated for its sensory attributes, proximate composition and invitro-protein digestibility (IVPD). Functional properties results showed an increase in water absorption capacity (WAC), a decrease in oil absorption capacity (OAC), decrease in Bulk Density (BD), swelling power and solubility index with residue addition. Pasting property results showed a drop in the value of peak, trough, breakdown and final viscosity with substitution while set back viscosity increased. Peak temperature decreased, but values for pasting temperature showed no significant difference between the control and the blends. Results for sensory evaluation showed equal preference for overall acceptability. Proximate composition results showed residue addition led to an increase in crude fibre and protein content with a drop in the carbohydrate value. Residue addition did not increase protein digestibility. Addition of fermented maize residue in chin-chin production can be another way of utilizing the fibre rich by-product of the production of fermented maize starch.

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Keywords: Chin-chin; fermented maize residue; pasting property; protein digestibility.

1. INTRODUCTION

The food processing industry generates a lot of by-product. These by-products include but not limited to seed, skin, pod, peel, pomace, hull, husk, core stem, rind and kernel [1]. These by-products are now known to be sources of bioactive compounds including dietary fibre [2]. The possibility of utilization of by-products of the food processing industry as soucres of dietary fibre, functional or novel fibre for manufacturing of human foods created the possibility of waste reduction and income generation [3].

Hulls, Husks and Brans are major by-products of the food grain industry, they possess a large potential for use as a source of insoluble dietary fibre [4]. Among brans of wheat, maize, oat, rice and rye, maize bran contains the highest amount of fibre, brans have also been used to replace flour in preparation of cookies [5].

Cookies produced with fermented maize residue gave acceptable sensory attributes when compared with the control and also increase in the fibre content [6].

Chin-chin is a traditional Nigerian snack prepared using wheat flour, butter, milk and eggs from which a stiff paste is made [7], the combined ingredients are kneaded together to form a firm dough which is flattened and cut into small square shaped pieces which are then deep fried [8].

Chin-chin is one food item that possesses a great deal of flexibility in terms of the ingredients used and method of preparation, it is often prepared hard and crunchy or soft and less crunchy. The colour of chin-chin and its flour makes it a major point of attraction to consumers. The major nutrients in chin-chin is carbohydrate and fat being a wheat product with added fat and fried.

Chin-chin is deficit in fibre. Fibre is an important dietary component that has several beneficial role to the body [9]. Substitution of refined wheat flour with a rich fibre source as in fermented maize residue has the potentials to improve the nutritional value of chin-chin aside its fibre content.

This investigation was therefore aimed at evaluating the effect of a novel fibre source addition on the sensory and nutritional properties of chin-chin.

2. MATERIALS AND METHODS

2.1 Production of Fermented Maize Residue

The procedure for “Ogi” production was employed. One kg of maize was cleaned to remove dirts and soaked in 4000ml of water for 2 days. The soaked seeds were milled using a grinding mill, sieved and the filtrate allowed tostand for 2 hours. The top water was decanted and the sediment (slurry) bagged to allow more water to drain out. The resultant wet cake was Ogi (fermented starch) [10].

The residue after sieving were dried at 50^0C for 12 hours, milled using the dry mill component of a blender and packed in container until ready for use.

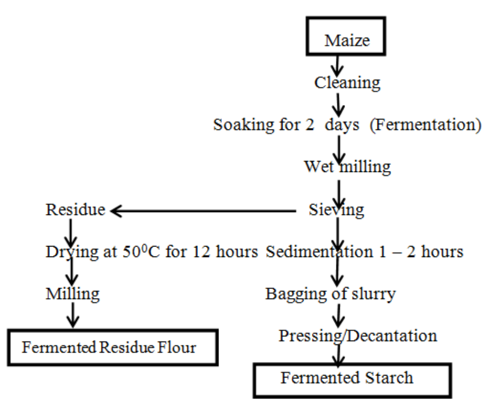

Fig. 1. Flow diagram for fermented maize residue

2.2 Preparation of Composite Blends

Table 1. Flour composition blend for chin-chin

Sample	Component A (Wheat Flour)	Component B (Residue Flour)
WF	100	-
WFRA	95	5
WFRB	90	10
WFRC	85	15
WFRD	80	20
WFRE	75	25
WFRF	70	30

Key: WF = Wheat flour 100%
WFRA = Wheat flour + Residue at 5% substitution
WFRB = Wheat flour + Residue at 10% substitution
WFRC = Wheat flour + Residue at 15% substitution
WFRD = Wheat flour + Residue at 20% substitution
WFRE = Wheat flour + Residue at 25% substitution
WFRF = Wheat flour + Residue at 30% substitution

Table 2. Recipe for chin-chin

Ingredients	Flour Proportion						
	WF	WFRA	WFRB	WFRC	WFRD	WFRE	WFRF
Wheat flour (%)	100	95	90	85	80	75	70
Fermented Residue (%)	0	5	10	15	20	25	30
Sugar (g)	25	25	25	25	25	25	25
Shortening (g)	50	50	50	50	50	50	50
Egg (g)	23.9	23.9	23.9	23.9	23.9	23.9	23.9
Baking powder (s)	56	56	56	56	56	56	56
Milk (g)	10	10	10	10	10	10	10

Source: Ceserani and Kinton (1990).
WF : Wheat Flour
WFR : Wheat + Residue (A, B, C, D, E, F)

2.3 Recipe for Chin-Chin Production

The chin-chin was prepared using the method of Ceserani and Kinton's [11] as shown in Table 2. The eggs and sugar were beaten manually for 2 minutes and was mixed with the flour for another 2 minutes. Milk was then added and the dough was then kneaded by hand on a flat clean stainless metal table for 5 minutes.

The dough was rolled on a sheet board to a uniform thickness (1.40 cm) and then cut into cubes of 0.5 cm length using a cutter. The dough cubes were then deep fried in vegetable oil (190^{0}C for 3 minutes) until brown, drained for 5 minutes, cooled and packaged for analysis.

2.4 Functional Property

Water and Oil Absorption Capacities were determined by the method of Beuchat [12], bulk density by the method described by Wang and Kinsella [13], Swelling volume, swelling power and solubility were carried out using the method of Takashi and Sieb [14].

2.5 Pasting Property

The pasting properties of wheat and its blends were carried out using a Rapid Visco-Analyser (RVA) model 3C, new port scientific Sydney) as described by Sanni et al. [15].

2.6 Sensory Evaluation

The panelists was made up of 23 final year students of the Department of Food Science and Technology, Rivers State University. They consist of 17 females and 6 males with in average3 age of 21 years. The panelist rinsed their mouth with a glass of water in between samples. The chin-chin were evaluated for the attributes of texture, colour, aroma and taste and overall acceptability using a five-point hedonic scale where I was designated very poor, 2 was fair, 3 was good, 4 very good and 5 designated excellent.

2.7 Proximate Composition

Proximate compositions were determined according to the methods of the Association of Official Analytical Chemist [16].

2.8 *In vitro*-Protein Digestibility (IVPD)

IVPD was carried out according to the method described by Monjula and John [17] with a minor modification. A known weight of the sample containing 16 mg nitrogen was taken in triplicate and digested with 1mg pepsin (Cat no P6887, sigma chemicals Ltd USA) in 15ml of 0.1N HCl at 37^0C for 2 hrs in an incubator (DHP – 9053A), Haris England). The reaction was stopped by the addition of 15ml 10% trichloroacetic acid (TCA). The mixture was then filtered quantitatively, through Whatman No. 1 filter paper. The TCA soluble fraction was assayed for nitrogen using the micro-kjeldahl method. Digestibility was estimated by using the following equation:

$$\text{IVPD (\%)} = \frac{\text{N in Supernatant} - \text{Enzyme N}}{\text{N in sample}} \text{ x } 100$$

2.9 Statistical Analysis

The experimental design was Complete Randomized Design (CRD). The statistical analysis was carried out using SPSS version 14 and the men values and standard deviation calculated. Data obtained were analysed using analysis of variance (ANOVA) to separate the mean.

3. RESULTS

3.1 Functional Properties

Table 3 showed the functional properties of wheat-fermented yellow maize residue flour blend.

The WAC ranged from 0.84 g/g in sample AAA to 1.13 g/g in sample A_6FYR, OAC ranged from 1.22 g/g in sample A_6FYR to 1.58 g/g in sample AAA, BD ranged from 0.71 g/ml in sample A_6FYR to 0.84/ g/ml in AAA. SP ranged from 8.20 g/g in sample A_6 FYR to 9.72 g/g in sample AAA while SI ranged from 19.42 in sample A_6FYR to 26.18% in sample AAA.

3.2 Pasting Properties

The pasting properties of wheat-fermented yellow maize residue composite flour are as shown in Table 4. The pasting properties are, Peak Viscosity (PV), Trough Viscosity (TV), Breakdown Viscosity (BV), Final Viscosity (FV), Setback Viscosity (SV), Peak Time (PT) and Pasting Temperature (P temp).

The peak viscosity decreased from 193.96 RVU in sample AAA to 151.04 RVU in A_6FYR. The Trough ranged from 85.88 RVU in A_6FYR to 100.58 RVU in AAA, the breakdown viscosity ranged from 65.17 RVU in A_6FYR to 96.67 RVU in AAA, Final Viscosity ranged from 183.75 RVU to 194.95 RVU in AAA, Set back viscosity ranged from 92.25 in AAA to 106.16 RVU in A_6FYR, Peak time ranged from 5.57 in A_6FYR to 5.90 RVU in AAA, while pasting temperature ranged from 49.35FYR to 50.48^0C in sample AAA.

Table 3. *Functional properties of wheat and fermented yellow maize residue composite flour

Sample **	Water Absorption (g/g)	Oil Absorption (g/g)	Bulk Density (g/ml)	Swelling Power (glg)	Solubility Index (%)
AAA	$0.84^a \pm 0.00$	$1.58\ ^a \pm 0.06$	$0.84^a \pm 0.00$	$9.72^a \pm 0.64$	$26.18^a \pm 0.25$
A_1FYR	$0.85\ ^a \pm 0.02$	$1.49\ ^a \pm 0.03$	$0.81^{ab} \pm 0.03$	$9.5^{ab} \pm 0.28$	$25.23^{ab} \pm 0.04$
A_2FYR	$0.88\ ^a \pm 0.02$	$1.39\ ^a \pm 0.04$	$0.81^{ab} \pm 0.01$	$9.19^a \pm 0.00$	$23.29^{ab} \pm 0.42$
A_3FYR	$0.94\ ^a \pm 0.02$	$1.37\ ^a \pm 0.15$	$0.77^{abc} \pm 0.01$	$8.63^{abc} \pm 0.26$	$22.82^{bc} \pm 1.69$
A_4FYR	$0.96\ ^a \pm 0.16$	$1.34\ ^a \pm 0.01$	$0.76^{bc} \pm 0.00$	$8.46^{bc} \pm 0.05$	$21.21^{cd} \pm 0.77$
A_5FYR	$0.99\ ^a \pm 0.14$	$1.30^a \pm 0.07$	$0.74^{bc} \pm 0.00$	$8.27^c \pm 0.15$	$22.12^{cd}0.14$
A_6FYR	$1.13\ ^a \pm 0.27$	$1.22\ ^a \pm 0.01$	$0.71^c0.04$	$8.20^c \pm 0.06$	$19.42^{abc} \pm 0.36$

** Values are Means of Duplicate Determinations ± Standard Deviation*
Means with different superscripts within a column are significantly (P<0.05) different (P>0.05).
*** Sample*
AAA = 100% Wheat Flour
A_1FYR = 95% Wheat: 5% Residue Flour
A_2FYR = 90% Wheat: 10% Residue Flour
A_3FYR = 85% Wheat: 15% Residue Flour
A_4FYR = 80% Wheat: 20% Residue Flour
A_5FYR = 75% Wheat: 25% Residue Flour
A_6FYR = 70% Wheat: 30% Residue Flour

3.3 Sensory Evaluation

Table 5 show mean sensory scores of chin-chin from wheat-fermented yellow maize residue composite flour. Colour ranged from 3.44 in A_2 FYR to 3.80 in AAA, Texture ranged from 2.92 in A_2 FYR to 3.80 in AAA, Aroma ranged from 2.76 in A_2 FYR to 3.52 in AAA, Taste ranged from 2.40 in A_2 FYR to 3.72 in AAA while overall acceptability ranged from 2.88 in A_2 FYR to 3.71 in AAA.

3.4 Proximate Composition

Table 6 showsthe proximate composition of chin-chin from wheat-fermented yellow maize residue composite flour. Moisture content (%) ranged from 6.67 in A3FYR to 8.13 in AAA, Ash (%) ranged from 1.15 in A6 FYR to 1.33 in AAA, Fat (%) ranged from 36.84 in A6 FYR to 42.21 in A2 FYR, Crude protein ranged from 7.52 in A3 FYR to 8.70 in A6 FYR, Crude fibre (%) ranged from 1.93 in AAA to 5.03 in A6 FYR while carbohydrate (%) ranged from 38.32 in A4 FYR to 43.70 in AAA.

3.5 *In vitro* Protein Digestibility

Table 7 show result of IVPD of wheat-fermented yellow maize residue chin-chin. The IVPD for chin-chin ranged from 21.52 in A6 FWR to 54.70% in AAA.

Table 4. Pasting properties of wheat flour and fermented yellow maize composite flour

Sample**	Peak 1 (RVU)	Trough (RVU)	Breakdown (RVU)	Final Visc (RVU)	Set back (RVU)	Peak time (Min)	Pasting Temperature (^{0}C)
AAA	193.96^a±1.24	100.58^a±0.01	96.67^a±1.65	194.95^a±0.01	92.25^a±0.00	5.90^a±0.04	50.48^a±0.11
A_1FYR	191.84^a±0.01	97.63^{ab}±1.00	96.34^a±0.23	193.08^a±0.00	96.96^{ab}±0.00	5.87^a±0.09	50.38^a±0.04
A_2FYR	183.92^b±2.71	94.17^b±0.00	93.88^a±0.64	192.75^a±0.00	97.34^{ab}±2.71	5.80^a±0.10	49.78^a±1.03
A_3FYR	183.92^b±0.00	90.04^c±2.06	89.75^b±0.01	188.42^b±0.71	98.58^a±0.01	5.77^a±0.05	49.05^a±0.14
A_4FYR	169.46^c±0.03	88.25^{cd}±0.30	81.21^c±0.30	187.13^{bc}±0.01	97.88^{ab}±1.21	5.63^a±0.14	50.68^a±0.18
A_5FYR	167.70^c±0.01	88.09^{cd}±1.29	79.63^c±2.06	187.08^{bc}±2.47	99.08^a±0.00	5.63^a±0.14	50.55^a±0.14
A_6FYR	151.04^d±0.41	85.88^d±0.42	65.17^d±0.00	183.75^c±0.71	100.16^a±2.71	5.57^a±0.14	49.35^a±0.28

** Values are Means of Duplicate Determinations ± Standard Deviation*
Means with different superscript within a column are significantly (P>0.05)different.
*** Sample*
AAA = 100% Wheat Flour
A_1FYR = 95% Wheat: 5% Residue Flour
A_2FYR = 90% Wheat: 10% Residue Flour
A_3FYR = 85% Wheat: 15% Residue Flour
A_4FYR = 80% Wheat: 20% Residue Flour
A_5FYR = 75% Wheat: 25% Residue Flour
A_6FYR = 70% Wheat: 30% Residue Flour

Table 5. Mean sensory scores of chin-chin from wheat and fermented yellow maize residue blends

Sample	Colour	Texture	Aroma	Taste	Overall Acceptability
AAA	3.80^a±0.866	3.80 ^{a}±1.187	3.52 ^{a}±0.963	3.72 ^{a}±1.137	3.71 ^{a}±0.988
A_1FYR	3.72 ^{a}±0.737	3.32 ^{a}±1.108	3.40 ^{ab}±0.913	3.72 ^{a}±0.980	3.54 ^{ab}±0.980
A_2FYR	3.44 ^{a}±0.961	2.92 ^{a}±1.152	2.76 ^{b}±0.879	2.40 ^{a}±1.052	2.88 ^{b}±0.862
A_3FYR	3.52 ^{a}±1.046	3.36 ^{a}±1.036	3.48 ^{ab}±0.963	3.44 ^{a}±1.158	3.45 ^{ab}±0.963
A_4FYR	3.48 ^{a}±0.770	3.08 ^{a}±1.077	3.20 ^{ab}±0.646	3.44 ^{a}±0.870	3.30 ^{ab}±0.957
A_5FYR	3.76 ^{a}±0.779	3.20 ^{a}±0.957	3.48 ^{ab}±0.770	3.64 ^{a}±0.91	3.52 ^{ab}±0.957
A_6FYR	3.72 ^{a}±0.843	3.16 ^{a}±0.898	3.48 ^{ab}±0.918	3.689 ^{a}±0.900	3.51 ^{ab}±0.963

** Values are Means of Duplicate Determinations ± Standard Deviation*
Means with different superscript within a column are significantly (P0<05) different.
***Sample, AAA =100% Wheat Flour, A_1FYR=95% Wheat: 5% Residue Flour, A_2FYR=90% Wheat: 10% Residue Flour, A_3FYR=85% Wheat: 15% Residue Flour, A_4FYR=80% Wheat: 20% Residue Flour, A_5FYR=75% Wheat: 25% Residue Flour, A_6FYR=70% Wheat: 30% Residue Flour*

Table 6. *Proximate composition of chinchin from wheat and fermented yellow maize residue flour

Sample**	Moisture Content (%)	Ash (%)	Fat (%)	Crude Protein (%)	Crude Fibre (%)	Carbohydrate (%)
AAA	$8.13^{a}\pm0.02$	$1.33^{a}\pm0.02$	$37.39^{b}\pm1.21$	$7.52^{c}\pm0.00$	$1.93^{d}\pm0.04$	$43.70^{a}\pm1.95$
A_1FYR	$7.62^{c}\pm0.21$	$1.28^{a}\pm0.01$	$40.96^{ab}\pm1.25$	$7.58^{b}\pm0.05$	$1.99^{d}\pm0.01$	$40.57^{a}\pm1.03$
A_2FYR	$7.29^{d}\pm0.03$	$1.22^{a}\pm0.00$	$42.21^{a}\pm1.89$	$7.67^{c}\pm6.23$	$2.69^{c}\pm0.05$	$38.86^{a}\pm1.72$
A_3FYR	$6.67^{abc}\pm0.16$	$1.23^{a}\pm0.00$	$40.11^{ab}\pm0.87$	$7.84^{c}\pm0.58$	$3.89^{b}\pm0.04$	$40.26^{a}\pm0.58$
A_4FYR	$7.00^{ab}\pm0.04$	$1.16^{a}\pm0.03$	$41.07^{a}\pm0.96$	$8.35^{b}\pm0.01$	$4.10^{b}\pm0.11$	$38.32^{a}\pm2.39$
A_5FYR	$7.38^{bc}\pm0.21$	$1.18^{a}\pm0.23$	$38.89^{ab}\pm0.02$	$8.32^{b}\pm0.00$	$4.75^{a}\pm0.25$	$39.48^{a}\pm0.72$
A_6FYR	$7.76^{abc}\pm0.11$	$1.15^{a}\pm0.02$	$36.84^{b}\pm0.09$	$8.70^{a}\pm0.05$	$5.03^{a}\pm0.06$	$40.52^{a}\pm0.08$

** Values are Means of Duplicate Determinations ± Standard Deviation*
Means with different superscript within a column are significantly (P<0.05) different.
*** Sample*
AAA =100% Wheat Flour, A_1FYR=95% Wheat: 5% Residue Flour, A_2FYR=90% Wheat: 10% Residue Flour, A_3FYR=85% Wheat: 15% Residue Flour, A_4FYR=80% Wheat: 20% Residue Flour, A_5FYR =75% Wheat: 25% Residue Flour, A_6FYR=70% Wheat: 30% Residue Flo

Table 7. *In vitro*-protein digestibility of wheat-fermented yellow residue chin-chin (%)

**Sample	Chinchin
AAA	$54.70^{a}\pm1.41$
A_1FYR	$48.13^{a}\pm0.00$
A_2FYR	$43.78^{bc}\pm0.11$
A_3FYR	$39.40^{c}\pm0.06$
A_4FYR	$39.38^{c}\pm0.04$
A_5FYR	$30.62^{d}\pm1.38$
A_6FYR	$21.52^{cd}\pm0.03$

** Values are Means of Duplicate Determinations ± Standard Deviation*
Means with different superscript within a column are significantly different (P>0.05)
*** Sample*
AAA =100% Wheat Flour, A_1FYR=95% Wheat: 5% Residue Flour, A_2FYR=90% Wheat: 10% Residue Flour, A_3FYR=85% Wheat: 15% Residue Flour, A_4FYR=80% Wheat: 20% Residue Flour, A_5FYR =75% Wheat: 25% Residue Flour, A_6FYR=70% Wheat: 30% Residue Flour

4. DISCUSSION

The functional properties of the wheat-fermented residue flours are as presented in Table 3.

The functional properties of food have to do with food functional indicators that determine their application and use for various food product. Hon et al. [18] reported that two reasons are responsible for the effect of dietary fibre on dough are its unique physico-chemical properties and the effect of starch and protein in wheat flour, they further posited that among all the functional properties hydroscopicity stands our affecting dough properties such as hardness, cohesiveness, resilience and cooking characteristics and further added that the porosity of the surface of dietary fibre could act as active carbon thereby engineering high water absorption.

The values of water absorption capacity (WAC) (gH_2O/g sample) ranged from 0.84 in control sample (AAA) to 1.13 in sample A6 FYR (30% residue flour), that is the capacity of the flour blend to absorb water increased with increase in substitution, which can be attributed to a dilution effect of the starch granules by the presence of the fermented maize residue flour.

Adebowale et al. [19] reported an increase in WAC of sorghum-wheat composite flour and attributed the high WAC to the loose structure of starch polymers and indicating also that low values is due to a compact structure. Mironeasia and Codina [20] reported an increase in the WAC of wheat flour-citrus flour dough with increase in the amount of citrus fibres and attributed these phenomena to the ability of citrus fibres to retain water within its matrix. The same observation was made by Oke, et al. [21] in wheat-tigernut pomace blends and this view was further upheld by soral-smietona et al. [22] in wheat-potato fibre preparation.

Values for oil absorption capacity (OAC) presented a downward trend with increase in residue flour. It should follow that an increase in hydroscopicity due to the presence of the maize residue fibre at graded level will obviously translate to a reduction in oil-absorption capacity owning to the non-polarity of the triglycerides molecule.

Bulk density (g/ml) decreased with increase of the residue flour. The bulk density is a function of particle size and density of the flour and its blend and this is a determinant in raw material handling and application in wet processing [21]. The observed trend is not out of place as the residue flour is lighter since it is without the starch component and now consists largely of bran and corn fibre. However, this observation is at variance with that obtained by Oke et al. [21] who reported an increase in wheat-tigernut pomace blends.

The swelling power of flours granules is an indication of the extent of associative forces within the granules [19]. Results for swelling power showed a decrease between the control and the blends, this can be as a result of dilution of the starch content of the wheat flour with the residue flour because starch is a critical component responsible for the swelling power of flours. The solubility index (%) decreased with increase in maize residue and this has implication for the soluble nutrients.

The pasting property is known as one of the most important properties that influences the quality and aesthetic considerations in the food industry due to their effect on texture, digestibility as well as the end use of starch based food commodities [19]. These properties are: Peak Viscosity, Trough viscosity, Final viscosity, set back viscosity, pasting temperature and pasting time.

Results of the pasting properties are as shown in Table 4. The peak viscosity decreased from 195.96 RVU in the control (AAA) to 151.04 RVU in sample A6 FYR (30% level of substitution). Trough viscosity decreased from 100.58 RVU in the control to 85.88 in sample A6FYR, Breakdown viscosity decreased from 96.67 in the control to 65.17 RVU in A6FYR, final viscosity also showed a downward trend from 194.95 to 183.75 RVU in sample A6FYR.

Oke et al. [21] also reported a decrease of peak viscosity from 135.9RVU to 113.6 RVU, Trough from 90.2RVU to 76.7RVU for wheat-tigernut pomace blends, breakdown viscosity also took a downward slide from 45.8RVU in the control to 36.0 RVU in the blend with the highest amount of tigernut pomace.

Peak viscosity is a parameter related to the capacity of starch to absorb water and swelling of the starch granules during heating [23]. This decrease in peak viscosity may be as a result of the competition for water between the maize residue and the starch granules.

Final viscosity depends on the starch content, amylose/amylopectin ratio [24]. With increase in the level of substitution with fermented yellow maize residue (FYR) flour, the relative content of starch in the samples decreases hence a decrease in the final viscosity. However, the result of the setback viscosity does not follow the observed trend above as values increased with substitution levels from 92.25 RVU in the control to 100.16RVU. This increase in the setback viscosity can be attributed to the higher water retention of dietary fibre a component of the maize residue which allows for redistribution of water molecules in doughs a factor making water less available for retrogradation [25]. The higher the setback viscosity the lower the retrogradation of the flour paste during cooling and the lower the staling rate of the product made from the flour [19]. This trend however deviated from the report of Liu et al. [23] who reported a decrease in setback viscosity with increase in the levels of wheat bran in wheat-wheat bran composite flour, this could possibly be that in our own case the fermented, maize residue does not consist of maize bran alone as there is residual starch.

Trough is the maximum viscosity value at the constant temperature phase of the RVA pasting profile and it measures the ability of the paste to withstand breakdown during cooling [19]. The value also decreased with increase in the amount of FYR, highest in the control (105.58 RVU) and least in sample A6 FYR (85.88 RVU).

The peak time which is a measure of the cooking time was highest in the control 5.90 mins and least, 5.57 mins in sample A6 FYR, and this indicates a decrease in peak time with substitution, but the values were not significantly different ($P > 0.05$), this therefore implies decrease of cooking time during food preparation with the blends.

The pasting temperature which provides an indication of the minimum temperature required for cooking did not show any significant difference between control and the blends. A higher pasting temperature indicates higher water binding capacity, higher gelatinization tendency and lower swelling property of starch-based flours due to a high degree of association between starch granules [19].

There was no significant difference ($P>0.05$) among the samples for colour and texture, but for aroma, the control was most preferred and the mean score 3.52 differ significantly (P<0.05) from the others. For the attribute of taste the controland A1FYR at 5% level of substitution were the most preferred. Result for overall acceptability indicated equal level of preference.

The moisture content was highest in the control (AAA) with a value of 8.13(%) and least in sample A_3FYR (6.67%) [19].

The ash content decreased with residue addition. The ash content indicates the total mineral and the residue from fermented maize consisting of bran, fibre and residual starch could not have led to an increase in the ash content. Chin-chin been a deep fried products gave a high result for fat with no consistency in the values as to the uptake of fat. The result showed a slight increase in the protein content, while value for carbohydrate decreased.

Also the IPVD of chin-chin produced from blends of wheat and fermented yellow residue flour in Table 7 also showed a decrease in IPVD, from 54.079 – 21.52% in chin-chin Invitro protein digestibility is a factor when assessing the nutritional status of a food. It is an index of protein quality. Friday et al. [6] also reported a decrease in IPVD of cookies substituted with fermented maize residue and reported that the decrease could possibly be as a result of the fact that the residue consisting largely of maize bran as its source of protein produce protein of low digestibility.

5. CONCLUSIONS

Addition of fermented maize residue to wheat flour increased the water absorption capacity of the composite flourwith a decrease in oil absorption capacity, bulk density swelling power and solubility index. Addition of fermented maize residue brought decrease in peak viscosity, trough viscosity, final viscosity and the setback viscosity, a decrease also in peak time with slight decrease of pasting temperature.

Addition of fermented maize residue produced chin-chin of acceptable sensory appeal, a slight increase in protein content. Addition of the fermented residue did bring about an increase in the fibre content of the chin-chin, but did not increase *in vitro*-protein digestibility but decreased the carbohydrate content.

This research has thus shown that an acceptable chin-chin can be produced with added fermented maize residue of up to 30% level of substitution.

DISCLAIMER

The products used for this research are commonly and predominantly used products in our area of research and country. There is absolutely no conflict of interest between the authors and produces of the product because we do not intent to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company, rather it was funded by the personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Joshni VK, Sharma SK. Food processing industrial wastes present scenario. In: Food process waste management, New India Pub. Agency, New-Delhi. 2011;1–30.
2. McKee LH, Latner TA. Underutilized source of dietary fibre. A review. Plant foods for human nutrition. 2000;55: 285-304.
3. Sharma SK, Bansal S, Margal M, Dixit AK, Guptal RK, Mangal AK. Utilization of Food processing by-products as dietary, functional and Novel fibre. A review critical reviews in food science and Nutrition. 2015;56:1647–1661.
4. Cole JT, Fahey Jr. GC, Merchen NR, Patil AR, Murray SM, Hussein HS, Brent Jr. JL. Soybean Hulls as a source of dietary fibre for dogs. Journal of Food Science. 1999;77:917–924.
5. Sharif MK, Masood SB, Faqir MA, Nawaz H. Preparation of fibre and mineral enriched rice bran supplemented cookies. Pakistan Journal of Nutrition. 2009;8(5): 571–577.
6. Owuno F, Kiin-Kabari DB, Akusu M. Effects of fermented maize residue on the physicochemical and nutritional properties of cookies. Current Journal of Applied Science and Technology. 2021;40(20): 26–33.

7. Akubor PJ. Protein contents, physical and sensory properties of Nigerian snack foods (Cake, chin-chin and puff-puff) prepared from cowpea-wheat flour blends. International Journal of Food Science and Technology. 2004;39:419–424.
8. Mepba HD, Achinewhu SC, Wachukwu CKC. Microbiological quality of selected street foods in Port Harcourt, Nigeria. Journal of Food Safety. 2007;27:2088.
9. Kataria D, Dalmig S. Processing and sensory properties of high fibre bakery products. International Journal of Environment and Agricultural Research. 2017;3(9):47 – 53.
10. Owuno F, Kiin-Kabari DB, Akusu M, Achinewhu S. Nutritional and Sensory properties of Gari enhanced with fermented maize residue flour. International Journal of Food Science and Biotechnology. 2021;6(2):59–65.
11. Ceserani V, Kinton R. Practical Cookery, Hodder and Arnold, H. and S, UK; 1990.
12. Beuchat LR. Functional and electrophorectic characteristics of succunylated peanut four protein. Journal of Agriculture and Food Chemistry. 1977;25:258–262.
13. Wang JC, Kinseila JE. Functional properties of novel proteins. Alfalfa leaf protein. Journal of Food Science. 1976;41:286–289.
14. Takashi S, Sieb PA. Paste and gel properties of prime corn starches with and without native lipids. Cereal Chemistry. 1988;65:474–483.
15. Sanni L, Maziya-Dixon B, Onabolu AO, Arowosa FB, Okechukwu RU, Aixon AGO, Waziri ADF, Ezedinma C, Semakula G, Lemchi JO, Akoroda M, Ogbe F, Farawal G, Okoro E, Getoloma C. Cassava Recipes for Household Food Security, IITA, Integrated Cassava Project, Ibadan, Nigeria; 2006.
16. AOAC. Official method of Analysis, Washington DC, USA, Association of Official Analytical Chemist; 2006.
17. Manjula S, John E. Biochemical Changes and Invitroprotein digestibility of the endosperm of germinating Dolichos Lablab. Journal of Science, Food and Agriculture. 1991;55:529–538.
18. Han W, Ma S, Li L, Wang X, Zhung X. Application and Development Prospects of Dietary Fibres in flour products. Journal of Chemistry. 2017;10:3441.
19. Adebowale AA, Adegoke SA, Adegunwa MO, Fetuga GO. Functional properties and biscuit making potentials sorghum wheat flour composite. America Journal of Food Technology. 2012;7(6):372–379.
20. Mironeasa S, Codina GG. Effects of citrus fibre additions on wheat flour dough rheological property. Journal of Faculty of Food Engineering Stefancel More University of Suceava, Roman’s. 2013; 12(4):322–307.
21. Oke EK, Tyani AO, Akinsola AO, Abiola OT, Ahamba RN. Functional, pasting and sensory properties of chin-chin produced from wheat-tigernutpomace blends. Natural Science. 2017;15(9): 74–79.
22. Soral-Smietang M, Walkowski A, Wronkowska M, Lewarutowic Z. Potato fibre preparation – chemical characteristics microstructure and functional properties in baking products. PolishJournal of Food and Nutrition Sciences. 2003;12(53):119–124.
23. Liu N, Ma S, Li L, Weng X. Study on the effect of wheat-bran dietary fibre on the rheological properties of dough. Grain and oil science and technology; 2019.
24. Tester RF, Morrison WR. Swelling and amylosization of cereal starches effects of amylopectin. Cereal Chemistry. 1990;67: 551–557.
25. Elis RB, Tabana O, Joseane B, Gabrula SS, Telma EB, Luiz CG. Rheological properties of Gari processed from dried chips. Journal of Food Process and Technology. 2016;5(1):1-6.

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