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Functional and Pasting Properties of Acha, Deffated Soybean and Groundnut Flour Blends

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Abstract Composite flour blends (acha/defatted soybean and groundnut flour) in the ratio of 100:0, 90:10, 90:5:5, 80:10:10, 70:15:15, 60:20:20 and 50:25:25 respectively were produced and analyzed for functional and pasting properties using standard methods. Functional properties indicated a decreasing level for bulk density 0.72-0.54(g/m) and least gelation concentration (LGC) 5.90-3.85(%) with increasing level of substitution of defatted soybean and groundnut flour, while there was an increase in dispersibility(%), oil absorption(g/100g), water absorption capacity (g/100g) and foam capacity(%) 68.00-72.50(%), 1.06-1.83(g/100g), 1.61-1.98(g/100g) and 1.96-5.62(%) respectively with increasing level of substitution of defatted soybean and groundnut flour. Result of pasting properties indicated a decreasing level for peak viscosity (297.38-44.00) RUV, trough (173.30-40.42) RUV, break down (126.59-2.83) RUV, final viscosity (253.09-106.25) RUV with increase in substitution of defatted soybean and groundnut flour. Setback (79.79-128.67)RUV, peak time (5.33-6.71)min and peak temperature (81.30-94.32°C) increased with an increase in the level of substitution of soybean and groundnut. The result showed that supplementing acha flour with defatted soybean and groundnut flour improved the water absorption capacity which is an important functional property required in food formulations especially those involving dough handling.

Keywords: *functional, pasting properties, acha, soybean, groundnut blends*

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1. Introduction

Acha *(Digitaria exilis*) also known as hungry rice is one of the indigenous and underutilized African cereals [1]. Ayo *et al* [2] reported that Acha is a cheap source of carbohydrate for man but low in oil and mineral). Acha is exceptionally tolerant to a wide condition particularly drought and poor soil which contributes to its availability all year round [3]. The cereal is uniquely rich in methionine and cystine and evokes low sugar on consumption [2]. The balancing of protein and amino acid profile of acha require supplementation with legumes and oil seed protein which are of high benefit [4]. Soybean also contains up to 45% protein [5] with a digestibility value of 91.41% [6] and has a good source of vitamins and mineral supplier adequate amount of different amino acids required for repairing the damaged body tissue). It could be an essential part of functional foods and could be used for enrichment of product quality [7]. Groundnut or peanut *(Arachis hypogea*) is a major crop grown in the arid and semi-arid zone of Nigeria. It is either grown for its nuts, oil or its vegetative residue (haulms). Defatted groundnut flour (DGF) produced from cake, blends easily and enhances the nutritive value of wheat and other flour [8] including flour from acha. The production of wheat in Nigeria is extremely low and far below domestic requirements [9] because the climate in Nigeria does not favour its cultivation [10] but very suitable for other cereal crops such as sorghum, millet, maize, acha etc. This study was done in an effort to promote the use of composite flour from locally grown crops. The quality of baked product depends on the proportional composition of the composites flour properties [11] hence the need to determine the optimium proportion of substitution for acha flour with defatted soybean and groundnut flour. Thus the aim of this work was to improve the quality of acha flour and to evaluate the functional and pasting properties of the blends of acha, defatted soybean and groundnut flour.

2. Materials and Methods

Acha *Digitaria exilis* (white) was bought from Kasuwon Monday Gurmin Gwari Kaduna, soybean *Glycine max* and groundnut *Arachis hypogea* was bought from Mile 3 Market Diobu, Port Harcourt.

2.1. Preparation of Acha Flour

Acha was manually cleaned by washing in clean tap water using local calabash to wash and de-stoned by sedimentation. Draining and drying in cabinet drier (at 50°C for 6 hrs.) the resultant dried acha was milled into flour using hammer mill (2014, hot model PC 180), according to Olapade *et al* [12].

2.2. Preparation of Defatted Soybean Flour

Soybean was sorted and thoroughly washed in clean running water and then sundried for 3-4 hours (tempering). The tempered seeds were cracked in an attrition type mill. Soybean hulls were removed by manual winnowing and then soaked in water for 24hours. It was then washed in clean running water and the grit boiled for 5mins at 100°C decanted and dried in an electric oven at 60°C for 12hours and thereafter dried soybean grit was milled to flour. The flour was mixed with food grade hexane and allowed to stand for 1hour before it was desolventized pouring into a muslin cloth and pressed using press screw and the residue was oven dried at 70°C for 6hours to obtain defatted soybean flour, according to the method of Clyde, [13].

2.3. Preparation of Defatted Groundnut Flour

Groundnut seeds were sorted to remove extraneous materials. Sorted seeds were subjected to roasting in aluminum pot over charcoal fire and stirred at intervals to ensure proper roasting for 20-25 min. Roasted seeds were allowed to cool and dehulled manually by rubbing and winnowing. The roasted seeds were milled in laboratory attrition mill. The milled flour was diluted with food grade hexane at a ratio of 500g: 200ml of hexane and allowed to stand for 1hour. It was then desolventized by pouring into a muslin cloth and pressed with a press screw. The residue was oven dried at 70°C for 6hours to obtain defatted groundnut flour, according to the method of Fekria *et al* [14].

2.4. Preparation of Flour Blends

Acha, defatted soybean and groundnut flour were properly mixed in different ratios. 100% acha flour was used as control and substitution up to 50% for both defatted soybean and groundnut flour.

2.5. Functional Properties of the Flour Blends

Bulk density, least gelation concentration (LCG), dispersibility, oil absorption, water absorption capacity (WAC) and foam capacity where determined using the method described by Onwuka [15].

2.6. Pasting Properties of the Flour Blends

This was determined using the rapid visco analyzer (RVA) Tecmaster, Perten instrumented) as described by Newport scientific (1998) as reported by Ehimen *et al* [16]. The sample was turned into slurry by mixing 3g of the sample with 25ml of water inside the RVA can. The can was inserted into the tower which was then lowered into the system. The slurry was heated from 50°C within 14min-12mins parameters to estimate was peak trough, final breakdown and set back viscosities, pasting and time to reach peak viscosity.

2.7. Statistical Analysis

All the data obtained for all the analysis carried out was subjected to statistical analysis using the software SPSS for windows version 21.0 statistical package (SPSS Inc.) and the significant difference between the means was analyzed using Duncan Multiple Range Test. All statistical tests were performed at 5% significant level.

Table 1. Blend Formulation

S/NO	SAMPLE CODES	RATIO OF COMPONENTS
1	A	100:0
2	AS	90:10
3	AG	90:10
4	ASG	90:5:5
5	ASG	80:10:10
6	ASG	70:15:15
7	ASG	60:20:20
8	ASG	50:25:25

3. Results and Discussions

The result of the functional properties of the flour blends in Table 2 showed that relative bulk density ranging from 0.54-0.72(g/ml). The range showed that there was a decrease in bulk density with a corresponding increase in substitution of defatted soybean and groundnut flour. This decrease may be due to the increased protein content which leads to break down of the strong amylose and amylopectin bonds. This result is in agreement with the findings of Anuonye *et al*., [17] for blends of acha and soybean blends. Bulk density is a function of flour wettability which influences packaging design and could be used in determining the required type of packaging material [18,19]. The least gelation concentration (LGC) of the acha flour alone was significantly higher than that of the blends with exception of samples AG and ASG (60:20:20) at 20% substitution of protein source which was not significantly different from 100% acha flour. Variation in the gelation concentration of flours could be attributed to the relative ratio of protein, carbohydrate and fat that made up the flours and their interaction with components [20]. This property of starch granules to form gel when subjected to heat is an important attribute in the formulation of baked foods. Dispersibility values ranging from 68.00-72.50 (%) indicated an increase with substitution of defatted soybean and groundnut flour. Oluwatoyin *et al*., [21], reported a mean value ranging from 45.50-51.0% of dispersibility for maize, millet, sorghum abakaliki and ofada white. Dispersibilty is a measure of reconstitution of flour or starch in water. The higher the value the better the sample reconstitutes in water and gives a fine constitutes during mixing [22]. Water absorption capacity (WAC) ranging from 1.60-1.74(g/100g) indicated an increase with increase in substitution of defatted soybean and groundnut flour. The values obtained from this study were within the values reported by [23] ranging from 1.50-1.90(g/100g) for water absorption capacity of blends of acha and soybean hull flour. Water absorption capacity is an important functional property required in food formulations especially those involving dough handling [24]. The ability of protein in flours to physically bind with water is a determinant of its water absorption capacity [25]. This is evident in AS (90:10) and AG (90:10) flour blend of acha soybean and acha groundnut respectively. Soybean with a better quality protein tended to absorb more water than groundnut, with groundnut inclusion reducing the water binding effect of soybean in the subsequent blends 5%-25% inclusion of defatted groundnut flour. Flours with high water absorption capacity have been reported to be good ingredients in bakery application as they improve handling characteristics. Oil absorption capacity ranging from 1.46-1.98 (g/100g) indicated a significant increase with increase in substitution of defatted soybean and groundnut flour. Oil absorption capacity is an important functional property that enhances mouth feel while retaining the flavour of foods [26]. Foam capacity did not differ significantly hence both legumes related well with each other and any could be used in combination with acha flour to improve the textural consistency and appearance of foods. Good foam capacity are desirable attributes for flours intended for the production of a variety of baked products such as cakes, cookies, muffins etc. [27] and so a complementing acha flour with either defatted soybean or groundnut flours is expected to give a product with improved texture, consistency and appearance.

The result of the pasting properties is shown in Table 3. The peak viscosity ranging from 44.00-297.38 RUV, indicates the ability of starch-based foods to swell freely before physical breakdown [22]. High peak viscosity is an index of high starch content [28]. This explains why 100% sample had the highest value indicating high starch content as compared to the blends. Trough viscosity also known as hold period is the point at which viscosity reaches its minimum during either heating or cooling process. Trough viscosity values ranged from 40.42-173.30RUV indicated a decrease in value with an increase in substitution of defatted soybean and groundnut flour. The values obtained were higher than values 39.60-59.19RUV reported for wheat and walnut [29] and lower than value of 205.01RUV for wheat flour as reported by [30]. These variations may be attributed to the addition of defatted soybean and groundnut. The significantly high trough viscosity observed in this study for 100% acha flour indicates the tendency of acha flour to break down during cooling. Breakdown viscosity ranging from 2.38-126.59 RUV showed that there was significant difference ($p \geq 0.05$) in the blends as substitution of defatted soybean and groundnut flour increased, indicating a decrease in breakdown viscosity. The higher the breakdown viscosity, the lower the ability of starch in the flour samples to withstand heating and shear stress while lower breakdown value indicates that the starch in question possess cross-linking properties [31]. The increase in the cross linking properties could be attributed to the increase in the protein components of the flour blends. Final viscosity ranging from 253.09-106.25 RUV showed a decrease in value as substitution of defatted soybean and groundnut flour increased. The values obtained were lower than the values reported for blends of wheat, plantain flour and bambara protein concentrates ranging from 249.84-342.81RUV according to [30]. Final viscosities are important in determining the ability of flour to form gel during processing Liang and King [32]. The values obtained were within the range reported by [29] for wheat and walnut blends RUV (95.51-252). Set back viscosity ranging from 65-128.69 RUV indicates an increase in setback viscosity as substitution of defatted soybean increased. Adebowale *et al.,* [33] reported that high set back value is an indication of the propensity of starch molecules to disperse in hot paste and re-associate readily during cooling. Peak time ranging from 5.33-6.71mins and pasting temperature ranging from 81.30-94.32°C, indicates an increase in peak time and pasting temperature as substitution of defatted soybean and groundnut increased. The values obtained from this study were within the range reported by [29] for wheat and walnut flour blends ranging from 6.49-6.84mins and 91.47-94.56°C for peak time and pasting temperature respectively. Peak time is a measure of the cooking time while pasting temperature is the temperature at which viscosity starts to raise [34]. Since pasting temperature is a measure of the minimum temperature required to cook a given food sample, flour blends with higher pasting temperature may not be recommended for certain product due to high cost of energy.

Table 2. Functional Properties of Acha, defatted Soybean, and Groundnut flour blends

Samples	B/D (g/m)	LGC(%)	Dispersibility (%)	WAC (g/100g)	O/A (g/100g)	F/C (%)
A (100:0)	0.69±0.24^{ab}	5.90±0.15^{a}	68.00±0.00^{d}	1.06±0.16^{a}	1.61±0.07^{bcd}	1.96±0.00^{a}
AS (90:10)	0.72±0.01^{a}	3.90±0.14^{b}	71.00±0.00^{b}	1.83±0.04^{a}	1.64±0.01^{bc}	5.62±2.53^{a}
AG (90:10)	0.66±0.01^{abc}	5.93±0.10^{a}	72.00±0.00^{a}	1.58±0.16^{a}	1.53±0.15^{cd}	2.90±1.33^{a}
ASG (90:5:5)	0.68±0.00^{abc}	3.95±0.78^{b}	70.00±0.00^{c}	1.65±0.08^{a}	1.60±0.06^{bc}	3.75±0.00^{a}
ASG(80:10:10)	0.63±0.02^{cd}	3.89±0.16^{b}	72.50±0.00^{a}	1.60±0.10^{a}	1.98±0.05^{a}	3.89±2.77^{a}
ASG(70:15:15)	0.69±0.00^{de}	4.00±0.01^{b}	71.00±0.00^{b}	1.78±0.07^{a}	1.79±0.05^{b}	2.89±1.32^{a}
ASG(60:20:20)	0.64±0.05^{bcd}	6.00±0.01^{a}	71.00±0.00^{b}	1.67±0.10^{a}	1.46±0.07^{d}	2.83±1.37^{a}
ASG(50:25:25)	0.54±0.03^{e}	3.85±0.21^{b}	70.00±0.00^{c}	1.74±0.10^{a}	1.70±0.01^{bc}	3.79±0.64^{a}

Means with the same alphabets in the same column are not significantly different for DMRT at 5% probability ($p \leq 0.05$)

KEYS: A= Acha flour, AS= Acha/defatted Soybean flour, AG= Acha/defatted Groundnut flour, ASG= Acha/defatted Soybean/defatted Groundnut flour, LGC= Least Gelation Concentration, BD= Bulk Density, WAC=Water Absorption Capacity, O/A= Oil Absorption, FC= Foam Capacity.

Table 3. Pasting Properties (RUV) of the Acha, defatted Soybean and defatted Groundnut flour blends

Sample	Peak	Trough	Break Down	Final	Set Back	Peak Time mins	Pasting Temp °C
A	297.38±5.01^{a}	173.30±6.89^{a}	126.59±5.42^{a}	253.09±14.26^{a}	79.79±7.37^{a}	5.33±0.18^{b}	81.30±1.48^{c}
AS	44.00±7.42^{d}	40.42±4.83^{e}	3.59±2.60^{d}	106.25±17.21^{a}	65.83±12.37^{a}	6.71±0.42^{a}	94.32±1.04^{a}
AG	44.88±3.71^{d}	41.58±2.83^{e}	3.30±0.88^{d}	109.54±3.83^{a}	67.96±1.00^{a}	5.87±0.01^{ab}	92.47±0.16^{ab}
ASG	131.07±3.52^{c}	95.75±15.09^{cd}	35.32±18.61^{c}	187.29±59.45^{a}	91.54±44.36^{a}	6.26±0.25^{ab}	91.52±1.48^{ab}
ASG	205.75±22.16^{b}	144.17±18.15^{ab}	61.59±4.01^{b}	217.88±27.16^{a}	73.71±9.01^{a}	5.85±0.16^{ab}	91.27±0.87^{ab}
ASG	181.63±41.08^{b}	121.71±32.05^{bc}	59.92±9.08^{b}	222.96±11.96^{a}	74.51±17.80^{a}	5.90±0.79^{ab}	86.65±8.06^{bc}
ASG	63.67±8.84^{d}	60.04±10.20^{de}	3.33±1.78^{d}	156.71±131.93^{a}	128.67±76.49^{a}	5.77±0.44^{ab}	93.02±0.62^{ab}
ASG	76.96±3.13^{d}	74.58±5.66^{de}	2.38±2.53^{d}	196.09±93.92^{a}	121.20±10.00^{a}	5.91±0.45^{ab}	92.80±0.35^{ab}

Means with the same superscripts on the same column are not significantly different for DMRT at 5% probability ($p \leq 0.05$)

KEYS: A=Acha flour, AS=Acha/defatted Soybean flour, AG=Acha/defatted Groundnut flour, ASG= Acha/defatted Soybean/defatted Groundnut flour.

4. Conclusion

The result obtained from the study has shown that supplementing of acha flour with 10% of both defatted soybean and groundnut flour resulted in considerable improvement of acha flour. The result of the functional properties of the composite blends showed that water absorption capacity and foam capacity had high values with increase in substitution of defatted soybean and groundnut flour. This is an indication that the composite flour could be used in making pastries like cake, biscuit and other snacks since high water absorption produces better baking quality flour and foam capacity is important in flours used for the production of baked products as it improves its texture and appearance. The pasting property results showed that the substitution of acha flour with defatted soybean and groundnut flour reduced the pasting properties, though the values obtained were still high and within the range for stable product during processing storage.

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