__Original Research Article__

Comparative study on Pasting and Functional properties of Composite flour produced from Acha (*Digitaria exilis*) starch, Chickpea (*Cicer arietinum)*and wheat (*Triticum aestivum)* blends.

Abstract

Introduction: Composite flour can relatively be any wheat flour composition with a particular substitution percentage of any type of flour produced from any other raw material. This is done to increase the nutritional profile, functional properties or further utilization of the said raw materials.

Objective: To produce composite flour from blends of acha starch, chickpea and wheat flour and determine the pasting and functional properties of the blends for food uses.

Methodology: Composite flour was produced in different blends using D-Optimal experimental runs. Pasting and functional characteristics is essential in estimating the properties of food paste and products during and after it is cooked.

Results: The pasting properties of the blends of the flour, the peak 1, trough 1, breakdown, final viscosity, set back, peak time(min) and pasting temperature(c) ranged between 1722.50 and 2483.5, 931.0 and 1723.00, 659.00 and 824.50, 1949.5.00 and 3267.0, 1095.50 and 1544.00, 5.44 and 6.00,76.28 and 88.83 respectively unit. Results for functional analysis of the flours blends, water absorption capacity, oil absorption capacity, bulk density, swelling power, solubility index ranged between 175 and 258, 186 and 232, 0.5588and 0.68, 4.52 and 6.08, 3.50% and 7.50% respectively.

Conclusion: The flour blends of Acha starch, chickpea flour and wheat flour showed that it can be good raw materials for food that requires high water and oil absorption properties.

Keywords; Composite flour, pasting properties, Functional properties

1. Introduction

Composite flour can relatively be any wheat flour composition with a particular substitution percentage of any type of flour produced from any other raw material. This is done to increase the nutritional profile, functional properties or further utilization of the said raw materials. In another words, it is a flour made by blending or mixing varying proportion of more than one non-wheat flour with or without wheat flour and used for production food products that are conventionally made from wheat flour and increase the essential nutrients in human diet. Functional properties are the fundamental Physico-chemical properties that reflect the complex interaction between the composition, structure, molecular conformation and physico-chemical properties of food components together with the nature of environment in which these are associated and measured (1). Pasting characteristic is important in predicting the behaviour of food paste during and after cooking. Attainment of the pasting temperature is essential in ensuring swelling, gelatinization and subsequent gel formulation during processing (2). Acha*(Digitariaexilis)* is an ancient cereal grain that is cultivated in most West Africa countries which is also known as Fonio, it is the tiniest grain in the millet family and a main source of protein (3). Nutritionally, Acha contains 67.1 to 91% carbohydrate, 7.0 to 11.5% protein, 11.30% crude fibre, 1.3 to 5.2% fat and 4619KcalGE/KG energy value. (4).

Chickpea (*Cicerarietinum*) is an annual legume crop which has a generous supply of carbohydrates, proteins, fibers lipids, and mineral contents that belongs to Fabaceae family Chickpea contains essentials vitamins such as niacin, riboflavin, thiamine, folate and vitamin A. It has several health benefits and in combination with other pulses and cereals helps in conditions such as Diabetes type 2, digestive diseases, cardiovascular diseases, and some cancers (5).

2. Materials and methods

2.1 Collection of materials

Acha grain was procured from Lupe market, FCT Abuja ,Nigeria. While the chickpea grains and wheat flour was purchased from Bazaar supermarket at Ilupeju in Lagos state, Nigeria.

2.2 Production of the flour blends

2.2.1 Acha starch

The acha starch was obtained using the method of (6). The acha grains was cleaned, steeped in water for 24 hours and wet milled. After which it was sieved and the starch was allowed to settle and the water was decanted so as to obtain the starch granules. The starch granule was dried using hot air oven and milled into fine powder. The starch obtained was stored in a cool dry place in an airtight container prior to usage.

2.2.2 Chickpea and wheat flour

The chickpea grains were screened for broken seeds, dust and stones. The seeds was washed with portable water and then soaked for 17hours, decanted and replaced with clean water in the ratio 1:10 (w/v) to the chickpea. The grains was boiled for one hour at 100ºC in an insulated kettle, decanted, dried for 8hours at 38-40C^0. The grain was grinded into powder and sieved with a 80-mesh stainless steel sieve (250um grain size distribution) to obtain fine flour. The obtained chickpea flour was packed in an airtight bag prior to usage (7). Wheat flour, Acha starch and Chickpea was mixed in different proportions with low and high limits set at (45: 60%), (30: 50%), and (5:20%) respectively. D-optimal design was employed because it puts into consideration the design constraints of the flour blend mixture as shown in Table 1. This resulted into fourteen (14) experimental runs as shown in Table 2.

3. Determination of pasting properties

Brabendervisco-amylograh (BVA), rheometer and rapid visco analyzer (RVA)were used to examine the pasting characteristics which includes breakdown, setback, peak, trough, final viscosity, peak temperature and peak time.

4. Determination of Functional properties

Swelling power solubility profile of starch was determined according to the method of (*8*). Water absorption capacity of the starch was determined according to the method of (9). Bulk density was determined using method of (10). Oil absorption capacity was determined using method of (11).

5. Statistical Analysis

All the data generated from the experiment analyzed using analysis of variance (ANOVA) using SPSS version 22.0 and the difference between significant mean values were separated at $p < 0.05$ probability level with Duncan's Multiple Range Test.

6. Results and Discussion

6.1 Pasting properties

Pasting properties of the composite flour from the Wheat- Chickpea flour and Acha starch is found on Table 3. Peak viscosity varied from 1722.50 to 2483.50RVU. Peak viscosity describes swelling of starch or water-binding capability during the process of heating. It is also an indication of the ability of the products to swell freely before their physical breakdown (12). The trough viscosity ranged from 931 to 1723RVU. High trough viscosity observed revealed that these combinations can survive high-heat treatments during processing. High trough values may represent low cooking losses and superior eating quality (13). The breakdown ranged between 659 and 824.50RVUBreakdown viscosity is a measure of degree of starch disintegration or the hot paste stability of the starch (14). The final viscosity ranged between 1949.50 and 3267.00 RVU. Final viscosities are essential in predicting the strength of the flour sample to form gel during heat processing. The final viscosity is the most commonly used parameter to determine a particular sample quality and indicates the stability to form various paste or gel after cooling (15). Setback viscosity indicates gel stability and potential for retrogradation (16). The setback ranged between 1018.50 and 1544.00RVU. Peak time of the composite flour blends varied between 5.44 and 6.00mins. The pasting temperature ranged between 84.80 and 88.83 ºC. Pasting temperature is the lowest temperature needed for gel to be formed, as well as the temperature at which the viscosity during the heating process goes rises. The granules begin to swell when the temperature is higher than that at which gelatinization occurs (17).

6.2 Functional Properties wheat-chickpea flour and acha starch

The mean value for functional properties of wheat-chickpea flour and acha starch for different experimental runs is as shown in Table 4. Significant ($p < 0.05$) difference was seen in the functional properties of the composite flour.The water absorption capacity of wheat-chickpea flour and acha starch ranged from 175.00 to 258.00%. Water Absorption Capacity (WAC) is the ability of a product to associate with water under a condition where water is limiting (18).High water absorption capacity could be attributed to the alteration in starch polymer structure while low value indicates compactness of the structure (19). The values obtained in this study were higher than the values (87-111%) reported (20) for blends of wheat, acha, cowpea and *Moringaoleifera*powder but agrees with the values(164-252%) reported (21). The bulk density ranged from 0.5588 to 0.7031g/ml.Bulk density is a determinant of flour expansion and an indicator of the porosity of food products (22).Low bulk density is desired in flour blends as it's contributes to lower dietary bulk, ease of packaging and transportation (23). The swelling power of wheat-chickpea flour and acha starch ranged between 4.52 and 6.08%. Swelling capacity actually describes the firmness of the bonds in the crystalline part of the starch granule which ultimately shows the easiness of cooking the flour or starch. Usually, the starch granules with more crystalline areas and stronger bonds swell less in cold or hot water as it forms a low viscosity paste with higher retrogradation (24). The oil absorption capacity of composite flour from wheat-chickpea flour and acha starch ranged between 186.00 and 232.00%.The ability of flours to absorb and retain oil may enhance flavour retention and improve mouth feel (25). Solubility of flours are affected by the extent to which water is taken up and held down within starch the granules and the increase in solubility figures could be traced to increase leaching of solubilized amylose molecules from expanded starch granules promoted by disruption of the starches. Factors capable of influencing the solubility of flours include flour composition and particle size, density and pH, processing conditions and storage conditions (26). The solubility of wheat-chickpea flour and acha starch ranged from 3.50 to 7.50%.

7. Conclusion

This research work has shown significant improvement in the functional and pasting properties of the flour resulting from the substitution of wheat with Acha starch and Chickpea flour in different formulations. The trend observed showed improvement in the functional properties of the product, especially in the water absorption and swelling power due to the addition of acha starch. This study confirmed that substitution of wheat flour using acha and chickpea improves the nutritional profile and hence increase in the utilization of them.

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Table 1.Blends formulation based on optimal of mixture design, design Constraints

Constraints	Low limits	High limits
A	45	60
B	30	50
C	5	20

A=Wheat flour, B=Acha starch, C=Chickpea flour

Table 2.Formulation of wheat, Acha starch and chickpea flour blends using D-optimal mixture design

Runs	Sample	WF	AS	CF
1	CAD	60.00	30.00	10.00
2	FDA	45.00	42.50	12.50
3	DEB	52.50	42.50	5.00
4	ORD	55.00	30.00	15.00
5	DOP	45.00	35.00	15.00
6	XAD	52.00	36.00	12.00
7	FEM	48.50	35.50	16.00
8	SNM	50.00	30.00	20.00
10	KLM	60.00	35.00	5.00
11	DEB	52.50	42.50	5.00
12	GTK	45.00	50.00	5.00
13	KLM	60.00	35.00	5.00
14	GTK	45.00	50.00	5.00

WF: Wheat Flour, AS: Acha starch, CF: Chickpea flour

Table 3.Pasting properties of Wheat- Chickpea flour and Acha starch

ER	WF	AS	CF	PV (RVU)	T (RVU)	BDV (RVU)	FV (RVU)	SB (RVU)	PT (Min)	PT(°C)
1	60.00	30.00	10.00	2035.50±47.37^{e}	1211.00±4.24^{e}	824.50±43.13^{k}	2606.50±58.68^{e}	1395.50±54.44^{f}	5.70±0.14^{d}	86.00±0.49^{d}
2	45.00	42.50	12.50	1722.50±38.89^{a}	931.00±65.05^{a}	791.50±26.16h	1949.50±26.16^{a}	1018.50±10.61^{a}	6.00±0.18^{g}	88.83±0.03^{h}
3	52.50	42.50	5.00	2385.50±58.68^{j}	1614.00±0.00^{j}	771.50±r58.68^{g}	3149.00±97.58^{j}	1535.00±97.58^{j}	5.87±0.09^{e}	86.83±1.73^{f}
4	55.00	30.00	15.00	1920.00±42.43^{d}	1155.00±19.79^{d}	765.00±22.62^{f}	2520.00±38.18^{d}	1365.00±18.38^{e}	5.64±0.05^{c}	85.63±0.03^{c}
5	45.00	35.00	15.00	2131.50±89.80^{h}	1388.50±38.89^{h}	743.00±50.91^{d}	2879.00±82.02^{h}	1490.50±43.13^{h}	5.57±0.05^{b}	85.60±0.07^{c}
6	52.00	36.00	12.00	1898.50±94.05^{c}	1089.50±94.05^{b}	809.00±0.00^{i}	2185.00±103.24^{b}	1095.50±9.19^{b}	5.44±0.05^{a}	76.28±0.53^{a}
7	48.50	35.50	16.00	2058.50±6.36^{g}	1359.50±20.51^{g}	699.00±26.87^{b}	2702.50±53.03^{f}	1343.00±73.54^{d}	5.74±0.09^{d}	86.35±0.07^{e}
8	50.00	30.00	20.00	1774.50±47.37^{b}	1115.50±43.13^{c}	659.00±4.24^{a}	2458.00±43.84^{c}	1342.50±0.71^{c}	5.64±0.05^{c}	88.10±0.00^{g}
9	45.00	35.00	20.00	2006.50±33.23^{e}	1292.00±9.89^{f}	714.50±23.33^{c}	2715.00±19.79^{g}	1423.00±9.89^{g}	5.57±0.05^{b}	85.98±0.60^{d}
10	60.00	35.00	5.00	2294.00±41.01^{i}	1481.50±23.33^{i}	812.50±17.68^{j}	2990.50±40.31^{i}	1509.00±16.97^{i}	5.93±0.00^{f}	86.38±0.04^{e}
11	52.50	42.50	5.00	2385.50±58.68^{j}	1614.00±0.00^{j}	771.50±58.68^{g}	3149.00±97.58^{j}	1535.00±97.58^{j}	5.87±0.09^{e}	86.83±1.73^{f}
12	45.00	5.00	5.00	2483.50±16.26^{k}	1723.00±39.59^{k}	760.50±23.33^{e}	3267.00±36.77^{k}	1544.00±76.37^{k}	5.90±0.04^{f}	84.80±1.06^{b}
13	60.00	35.00	5.00	2294.00±41.01^{i}	1481.50±23.33^{i}	812.50±17.68^{j}	2990.50±40.31^{i}	1509.00±16.97^{i}	5.93±0.00^{f}	86.38±0.04^{e}
14	45.00	5.00	5.00	2483.50±16.26^{k}	1723.00±39.59^{k}	760.50±23.33^{e}	3267.00±36.77^{k}	1544.00±76.37^{k}	5.90±0.04^{f}	84.80±1.06^{b}

Mean values with different superscripts within the same column are significantly different ($p>0.05$); CPF: Chickpea flour

N.B: ER- Experimental runs, AS- Acha starch, CF- chickpea flour, PV- peak viscosity, T-Trough, BDV- Breakdown viscosity, F-Final viscosity, SB- Setback viscosity, PT- Pasting time, PT- Pasting Temperature

Table 4: Functional Properties of Wheat-Acha starch -Chickpea Composite Flour

Experimental Runs	WF	AS	CPF	WAC (%)	BD(g/ml)	S Pr (%)	OAC (%)	SI(g/ml)
1	60.00	30.00	10.00	183.00±0.02^{b}	0.7031±0.01^{k}	4.73±0.08^{c}	216.00±0.07^{bc}	4.00±0.00^{b}
2	45.00	42.50	12.50	258.00±0.03^{d}	0.5588±0.00^{a}	5.17±0.15^{g}	186.00±0.02^{a}	7.50±0.71^{c}
3	52.50	42.50	5.00	182.00±0.01^{b}	0.5775±0.35^{c}	5.00±0.01^{ef}	232.00±0.03^{e}	4.00±0.00^{b}
4	55.00	30.00	15.00	192.00±0.02^{c}	0.6667±0.00^{d}	4.52±0.02^{a}	213.00±0.02^{b}	3.50±0.71^{a}
5	45.00	35.00	15.00	190.00±0.02^{c}	0.6792±0.03^{i}	4.77±0.00^{c}	226.00±0.08^{d}	4.00±0.00^{b}
6	52.00	36.00	12.00	181.00±0.01^{ab}	0.6712±0.02^{f}	4.97±0.06^{e}	219.00±0.06^{c}	4.00±0.00^{b}
7	48.50	35.50	16.00	180.00±0.01^{a}	0.6733±0.00^{g}	4.64±0.03^{b}	221.00±0.05^{c}	3.50±0.71^{a}
8	50.00	30.00	20.00	189.00±0.01^{bc}	0.6800±0.00^{j}	4.93±0.05^{e}	212.00±0.03^{b}	3.50±0.71^{a}
9	45.00	35.00	20.00	193.00±0.01^{c}	0.6684±0.05^{e}	4.83±0.03^{d}	220.00±0.02^{c}	4.00±0.00^{b}
10	60.00	35.00	5.00	175.00±0.01^{a}	0.6756±0.00^{h}	6.08±0.22^{h}	209.00±0.02^{b}	4.00±0.00^{b}
11	52.50	42.50	5.00	182.00±0.01^{b}	0.5775±0.35^{c}	5.00±0.01^{ef}	232.00±0.03^{e}	4.00±0.00^{b}
12	45.00	50.00	5.00	183.00±0.02^{b}	0.5608±0.1^{b}	5.17±0.01^{g}	229.00±0.03^{d}	4.00±0.00^{b}
13	60.00	35.00	5.00	175.00±0.01^{a}	0.6756±0.00^{h}	6.08±0.22^{h}	209.00±0.02^{b}	4.00±0.00^{b}
14	45.00	50.00	5.00	183.00±0.02^{b}	0.5608±0.1^{b}	5.17±0.01^{g}	229.00±0.03^{d}	4.00±0.00^{b}

Mean values with different superscripts within the same column are significantly different ($p<0.05$); CPF: Chickpea flour, WAC: Water absorption capacity, OAC: Oil absorption capacity

WF-Weat Flour, AS- Acha Flour, CPF, Chickpea flour, WAC – Water absorption capacity, BD-Bulk Density, S P-Swelling power, OAC- Oil absorption capacity, SI- Solubility Index