

Effect of Enzymatic Modification Period on Pasting Properties and Functional of Two Varieties of Acha Starch (*Digitaria Iburua* and *Digitaria Exilis*)

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ABSTRACT

Native starches are starches in their pure original form and may not be suitable for many food applications. The use of enzymes to modify starch results in development of low molecular weight, linear short chains fractions of amylopectin, increases the quantity of resistant starch content and promotes freeze thaw stability because amylopectin branches prevent syneresis in the gel network. The effects of enzymatic modification period on the pasting and functional properties of the two Varieties of Acha (*Digitaria exilis* and *Digitaria Iburua*) starch were investigated. Acha grains were modified with Enzymes for 30mins, 45mins and 60 mins and non-modified Acha grains served as control. The modified starches were evaluated for pasting and functional properties using standard procedure. Results obtained shows: Peak viscosity (2760.00-3752.00RVU), Trough viscosity (1717.00-2888.00RVU), breakdown (713.00-1881.00RVU), final viscosity (2910.00- 4399.00 RVU), setback viscosity (1074.00-1652.50), peak time (4.77-6.10mins), pasting temperature (78.28-80.70°C); water absorption capacity (2.03-2.28g/cm³), oil absorption capacity (2.24-8.20g/cm³), bulk density (0.81-4653%), solubility index (1.00-4.12%), swelling power (5.11- 11.50g/cm³) respectively. Enzymatic modification of the two Varieties of Acha grains enhances its functional and pasting properties of Acha based foods.

Keywords: Starch, Enzymatic Modification, Functional and Pasting Properties.

INTRODUCTION

Acha (*Digitaria exilis Spp*), also called “Fonio” and Hungry rice, is a tiny seeded c classified amongst the millet’s cereal, native to West Africa, especially Nigeria. It is mostly eaten whole, but can be processed into flour to become a multifaceted raw material, which can be used in the preparation of beverages, breakfast meals, gruels and porridges. Acha is a rich source of cysteine and methionine, which are beneficial to the health of humans but not readily available in common cereals. Acha varieties majorly cultivated in West African countries (Nigeria inclusive) are *Digitaria exilis* or and *Digitaria iburu* and yearly production is estimated at about 250,000 tonnes (Ukim et al., 2018). Acha is an underutilized crop which is extensively cultivated in commercial quantities in some states in Nigeria (Wilma et al., 2018). The black Acha (*Digitaria iburua*) has a nutritional composition of protein (8.75%), fat (4%), crude fiber (1.03%), carbohydrate 76.91% while the white Acha (*Digitaria exilis*) has a composition of protein (7.11%), fat (3%), crude fiber (0.79% and 79.72% carbohydrate (0.79%) (Idris et al., 2015).

Starch serves as one of the life-sustaining chemical energy that is continuously reproduced by the process of photosynthesis. The major sources of starch are plants which are located in the granules of crops such as cereals, stems, roots and tubers (Zubair and Osundahunsi, 2016). Starch can be characterized by the constituent of its granules i.e., size of the granules, shape and ratios of amylose (15-30%) to amylopectin (70-85%) (Yadav and Majumder, 2017). Currently 30% of the world’s enzymes production is made up of enzymes that convert or modify starch into malto-dextrin, glucose and fructose syrups or modified starches. As a result, carbohydrate enzymes are crucial for several processes in the baking and food industries. Their responsibilities include the manufacture of food raw materials, the improvement of quality product and the advancement of efficient food processing (Sung et al., 2017). Specifically, the aim of this study is to evaluate the effect of Enzymatic modification period on functional and pasting properties starches from Acha (*Digitaria exilis* and *Digitaria iburua*).

MATERIALS AND METHODS

Two varieties of Acha grains (*Digitaria exilis* and *Digitaria iburua*) were purchased from Lupe market, FCT Abuja, Nigeria. The enzyme (alpha-amylase) for modification was purchased from Ojota chemical market in Lagos, Nigeria.

Starch Preparation

The method applied by (Salcedo-Mendoza *et al.*, 2018) was used to determine alpha-amylase activity. To modify the Acha starch, 500g of dry milled Acha grains was dissolved in 120ml of water, then dosages of alpha -amylase enzymes (30g/L) was added to the Acha slurry and incubated at different times (30, 45 and 60 minutes). The slurry was poured into a muslin cloth placed over a bowl while the starch was rinsed out with water, after which the starch was allowed to sediments for the period of 8 hours. After sedimentation the water was decanted and the starch dried at 70°C for 3 hours.

Determination of Functional Properties of Starch Samples

Functional properties (bulk density, water absorption capacity (WAC), oil absorption capacity (OAC), solubility index and swelling power) were determined using method describe by Oladele and Aina (2007).

Determination of Pasting Properties of Starch Samples

Pasting properties (peak, Trough, breakdown, peak time, final viscosity, setback and pasting temperature) were determined using method describe by Sanni et.al. (2004).

STATISTICAL ANALYSIS

Data obtained were subjected to analysis of variance (ANOVA) Using SPSS version 21.0 and differences significant means value were evaluated at $P < 0.05$ probability level using Duncan's.

RESULTS AND DISCUSSION

Functional Properties

The results of functional properties of starch obtained by enzymatic modification method of Acha are presented in Table 2. Water absorption capacity (WAC) ranged from 1.93g/cm³ to 2.28g/cm³. Sample OGU (30 minutes enzyme modification starch of white Acha) had the lowest value and FDE (45 minutes enzyme modified starch of black Acha) had the highest value. WAC is the ability of a product to associate with water under a condition where water is limited (Adepeju et al., 2014). The result shows a low water absorption capacity of the modified starch and this is an indication that the starches will have a good water absorption capacity and also that the black Acha with 45 minutes enzyme modification was better than the sample modified at 30minutes. Oil absorption capacity is an important property in food formulation because fat improves the flavor and mouth feel of food. The Oil absorption capacity ranged from 2.24g/cm³ to 2.46g/cm³. Sample FDE (45 minutes enzyme modified starch of black Acha) had the least value and sample SHO (30 minutes enzyme modified starch of black Acha). The result of oil absorption capacity obtained is high which is probably due to low level of protein in Acha starch. Bulk density ranged from 46.53% to 67.13%. Sample OND (45 minutes enzyme modified starch of white Acha) had the lowest value and FDE (45 minutes enzyme modified starch of black Acha) had the highest value. Bulk density is a measurement of heaviness of solid sample which is important in determining the type of packaging material required, material handling and application in wet processing in the food industry (Ibikunle et al., 2019). The high bulk density in these modified starches may be due to the activity of the alpha-amylase in the starch granules and this indicates their suitability and stability for use in various food products. Solubility index ranged from 1.00% to 1.50% sample OND (45 minutes enzyme modified starch of white Acha) had the lowest value and SHO (30 minutes enzyme modification starch of black Acha) had the highest value. The low solubility index of the modified Acha starches indicates the ability of these starches to dissolve in water or an aqueous solution. The swelling power ranged from 5.11g/cm³ to 5.53g/cm³. Sample MST (60 minutes enzyme modified starch of white Acha) had the lowest value and FDE (45 minutes enzyme modified starch of black Acha) had the highest value. The swelling ability of starch is important in many food applications as it measures its ability to imbibe water (Aidio et al., 2022). The high swelling power of the modified starches maybe due to amylose content of the Acha starch.

Pasting Properties

Results of the pasting properties of Acha starches obtained from enzymatic modification are shown in Table 3. The peak viscosity of the enzymatic modified starch ranged from 3555.00RVU to 3752.50RVU. Sample OGU (30 minutes enzyme modified starch of white Acha) had the lowest value of peak viscosity and sample MST (60 minutes enzyme modified starch of white Acha) had the highest value. This result may be attributed to the modification time of alpha-

amylase activity on the starch, as the enzyme modification time increases starch chains were gradually broken down into smaller pieces also the higher peak viscosity in sample MST (60 minutes enzyme modified starch of white Acha) may be traceable to its larger granules size after modification. Starches with larger granule size undergo gelatinization relatively faster than smaller granule functions due to its molecular bonds (Tsakama et al., 2010). The trough viscosity ranges from 1717.00RVU to 2888.00RVU. Sample OGU (30 minutes enzyme modified starch of white Acha) had the lowest value and SHO (30 minutes enzyme modified starch of black Acha) had the highest value, high trough viscosity gives an indication of the ability of the starch to withstand breakdown during cooling. Therefore, the higher the trough viscosity the greater the possibility of the starch to withstand breakdown during cooling. Breakdown viscosity values ranged from 713.00RVU to 1881.00RVU. Sample FDE (45 minutes enzyme modified starch of black ACHA) had the lowest value and sample MST (60 minutes enzyme modified starch of white Acha) had the highest value. This result may be attributed to the time of modification and the activity of alpha-amylase on the starch which may have affected the amylose content, according to (Venema et al., 2014) amylose content is assumed to have a marked influence on the breakdown viscosity. Breakdown viscosity describes the possibility of starch to collapse during cooling or the extent of disintegration of granules or stability of paste (Ojo et al., 2017; Addy et al., 2014). Low value of breakdown of viscosity reflects better stability of the modified starch to resist heating and shear stress during cooking (Ezeocha and Okafor, 2016). Hence, sample FDE (45 minutes enzyme modified starch of black Acha) with the lowest breakdown have a better stability to undergo shear stress. Final viscosity is used to determine a starch capacity to form a gel after cooking or in the process of cooling (Ikegwu et al., 2010). The final viscosity ranged between 3246.00RVU and 4399.00RVU. Sample OGU (30 minutes enzyme modified starch of white Acha) had the lowest value and sample FDE (45 minutes enzyme modified starch of black) had the highest value. This result obtained is higher than the result reported by (Akram et al., 2017) who obtained 2877.75RVU to 1726.71RVU in effect of modified cereal starches on dough and bread quality. This may be attributed to the different type of modification method used, Akram et al., (2017) used physical modification (Heat moisture treatment) in modifying rice and corn starch while in this study enzyme modification was used. Setback viscosity indicates the retrogradation tendency of cooked starch during cooling (Ojo et al., 2017). The setback viscosity ranged from 1398.00RVU to 1652.50RVU. Sample OND (45 minutes enzyme modified starch of white Acha) had the lowest value and sample CRO 60 minutes enzyme modified starch of black Acha) had the highest value. The result obtained is higher than the result reported by (Sindihi et al, 2019) who obtained 846RVU to 1756 RVU in the setback viscosity of modified starches of common buckwheat, this result may be due to difference in modification time of the alpha-amylase on the starches. The higher setback viscosity obtained will have lower potentials for retrogradation of the starches. This starch will have lesser ability to form gels after cooling and form gels of high rigidity when utilized in food product. High setback is associated with a high degree of among starch molecules caused by hydrogen bonding (Okereke et al., 2022). Peak time is the lowest time required for the starch gelatinizes. The peak time range from 4.77 minutes to 6.10 minutes. Sample MST (60 minutes enzyme modified starch of white Acha) had the lowest peak time and Sample FDE (45 enzyme modified starch of black Acha had the highest peak time). The result from this study showed a low peak time which implies low energy consumption to gelatinize. The pasting temperature is the temperature when viscosity first by at least 2RVU over a 20 second period (Bakare et al., 2012). The pasting temperature range from 78.28oC to 80.70oC.

Sample MST (60 minutes enzyme modified starch of white Acha) had the lowest pasting temperature and sample FDE (45 minutes enzyme modified starch of black Acha) had the highest pasting temperature. From the result, there is correlation of pasting time with the pasting temperature, as lower the pasting temperature of the modified starch the shorter the pasting time. Therefore, sample MST (60 minutes enzyme modified starch of white Acha) will generate gains in time and energy that other enzyme modified starch when utilized in food production.

CONCLUSION

The study showed the functional and pasting properties of starch from the two Varieties of Acha grains modified with enzymes at different time of 30 minutes, 45 minutes and 60 minutes. The water absorption capacity, oil absorption capacity, solubility index and swelling power showed significant increase with decrease in the time of enzymatic modification, expect from bulk density which only shows increase with 45 minutes enzymatic modification. The Pasting properties of the starch determined by RVA showed that starch from the two Varieties of Acha grains that was modified with higher temperature (60minutes) had higher Pasting characteristics (peak 1, breakdown, setback, pasting temperature) expect from Trough1, final viscosity, and peak time which was higher with shorter Enzymatic modification time (30minuted and 45minutes). Generally, the results indicate the enzymatic modification at different period had a significant effect on the parameter studied.

Table 1: Sample Codes with Steeping Time

SAMPLE CODES	SAMPLE CODES WITH STEEPING TIME
SHO	30 minutes enzyme modified starch of black Acha
FDE	45 minutes enzyme modified starch of black Acha
CRO	60 minutes enzyme modified starch of black Acha
OGU	30 minutes enzyme modified starch of white Acha
OND	45 minutes enzyme modified starch of white Acha
MST	60 minutes enzyme modified starch of white Acha
WCF	Control

Table 2: Functional Properties of Acha starches obtained from enzymatic modified starch

samples	WAC(g/cm ³)	OAC(g/cm ³)	BD %	SI%	SP%
WCF	2.11±0.01 ^a	8.20±0.02 ^a	0.81±0.40 ^a	4.12±0.01 ^b	11.50±0.7 ^b
SHO	2.24±0.03 ^d	2.46±0.08 ^c	50.22±0.03 ^d	1.50±0.71 ^b	5.49±0.02 ^{cd}
FDE	2.28±0.04 ^d	2.24±0.07 ^a	67.13±0.00 ^g	1.00±0.00 ^a	5.53±0.13 ^e
CRO	2.03±0.04 ^b	2.42±0.05 ^c	50.43±0.03 ^e	1.00±0.00 ^a	5.52±0.03 ^e
OGU	1.93±0.04 ^a	2.34±0.00 ^b	50.24±0.02 ^d	1.50±0.71 ^b	5.40±0.07 ^b
OND	2.02±0.02 ^b	2.33±0.03 ^b	46.53±0.02 ^c	1.00±0.00 ^a	5.45±0.13 ^{bc}
MST	2.03±0.01 ^b	2.44±0.02 ^c	52.72±0.02 ^f	1.00±0.00 ^a	5.11±0.04 ^a

NB: Results are presented as Mean ± Standard Deviation of triplicate values. Same superscripts along each column are not significantly different at p<0.005

Table 3: Pasting Properties of Acha starches obtained from Enzymes modified starch

Sample	Peak 1 (RVU)	Setback (RVU)	Trough 1 (RVU)	Peak Time (min)	Breakdown (RVU)	Pasting Temperature (°C)	Final Viscosity (RVU)
WCF	2760.00±5.56 _a	1074.00±38.18 _d	1836.00±69.2 ^{9b}	5.43±0.05 ^c	924.00±53.74 ^c	76.85±12 ^b	2910.00±31.11 _a
SHO	3686.00±4.42 _c	1496.00±12.03 _c	2888.00±93.33 ^f	6.00±0.00 ^d	798.00±50.91 ^b	79.10±0.07 ^c	4384.00±26.69 ^f
FDE	3688.00±4.96 _c	1424.50±20.51 _b	2874.50±74.24 ^f	6.10±0.04 ^d	713.00±28.28 ^a	79.08±0.00 ^c	4399.00±53.74 _g
CRO	3672.50±2.92 _b	1652.50±14.71 ^f	2609.00±158.3 ^e	5.70±0.14 ^c	1063.50±18.31 ^d	80.70±0.00 ^d	4261.50±17.68 _e
OGU	3555.00±4.24 _a	1529.00±50.91 _d	1717.00±53.74 ^a	4.84±0.05 _a	1838.00±49.49 ^e	78.35±0.07 ^a	3246.00±29.82 _b
OND	3890.50±3.23 _d	1398.00±10.48 _a	2049.50±82.73 ^d	4.97±0.05 ^b	1841.00±49.50 ^e	78.73±0.60 ^a	3447.50±24.75 _d
MST	3752.50±2.12 _e	1557.00±10.40 _e	1871.50±24.74 ^b _c	4.77±0.05 ^b	1881.00±26.87 ^f	78.28±0.03 ^a	3428.50±23.33 _c

NB: Results are presented as Mean ± Standard Deviation of triplicate values. Same superscripts along each column are not significantly different at $p < 0.005$

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