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Evaluation of functional and pasting properties of different corn starch flours

Makanjuola Olakunle Moses[1*], Makanjuola John Olanrewaju[2]
[1] Department of Food Technology, The Federal Polytechnic, Ilaro, Ogun State, Nigeria
[2] Department of Science Laboratory, The Federal Polytechnic, Ilaro, Ogun State, Nigeria

Abstract
The functional and pasting properties of starch flours obtained from three (3) varieties of maize (corn) were investigated using standard analytical methods. The water absorption capacity ranged from 1.98g/mi – 2.32g/ml while the swelling power varied from 8.70g/g -15.00g/g, showing significant differences (P<0.05) between solubility index (3.89%-5.28%) while 3.15 NTU, 4.65NTU and 5.17 NTU were obtained as turbidity levels for white corn starch flour, yellow corn starch flour and pop corn starch flour respectively. The result revealed significant differences (P<0.05) in all the pasting properties evaluated suggesting that both the functional properties and pasting properties of starch will go a long way in enhancing the functionality and influencing their usefulness in food systems.

Keywords: evaluation, functional properties, pasting properties, corn starch flour

Introduction

Maize (*Zea mays)* is the third most important crop and major source of energy (starch) and other nutrients for humans and livestock in the world. In Sub-Sahara Africa, maize is a staple food for an estimated 50% of the populace and provide 50% of the basic calories. It is an important source of carbohydrate, protein, iron, vitamin B and minerals, (Chandharg, 1983). Maize is the third most important cereal in the world after rice and wheat and ranks fourth after millet and rice in Nigeria. (Ji *et al*; 2003) [2]. It has greater nutritional value as it contain 72% starch, 10% protein, 4.8% oil, 8.5% fibre, 3.0% and 1.7% ash (Chandharg, 1983).

Corn starch is a valuable ingredient to the food industry, being widely used as thickener, gelling agent, bulking agent and water retention agent (Singh *et al*., 2003) [3]. Starch is a naturally water soluble molecule of botanical origin. It is birefringent, meaning that when viewed under polarized light, a dark cross is seen (Buelon *et al*., 1998) [4]. The molecular structure of starch is made up two compounds; amylose and amylopectin. In most types of starch, 72-82% is amylopectin and 18-33% is amylose. Amylose is a linear molecule having b1-4 linked alpha-D-glucopyransyl units. Some amylose molecules are slightly branched with a few (1^6) branched linkages (Buelon *et al*., 1983). Amylopectin is the other molecule that makes up starch. Unlike amylose, it is highly branched, made up of short chains of alpha-D-glycopranosyl units, linked mostly through (1^4) linkages (Miles *et al*., 1985) [23].

Functionality as applied to food ingredients is defined as any property apart from nutritional attributes that influences the ingredients usefulness in foods (Crosbie, 2004). Several researchers have characterized the pasting properties of starches from different corn types and observed considerable variability in these properties (Ji *et al*., 2003) [2], Seetharam *et al*., 2001). The effect corn types on the physic chemical, thermal, morphological and rheological properties of corn starches was studied by Singh *et al*., 2003. Ji *et al* (2003) [3] used a texture analyzer for studying the gel properties of starches from selected corn types and find significant differences among them. The textural properties of 13 selected Argentinean corn landruces with significant variability in hardness between them after storage was studied (Seetharaman *et al*., 2001). Also reported by Hatche *et al*., (1999) [7] (was that cooking time shortened with increasing water absorption with minimal effect on textural attributes of cooked alkaline noodles. However, the objectives of this present work are to evaluate the functional properties as well as pasting properties of three different corn starch flours with a view to knowing their suitability as ingredients in food systems.

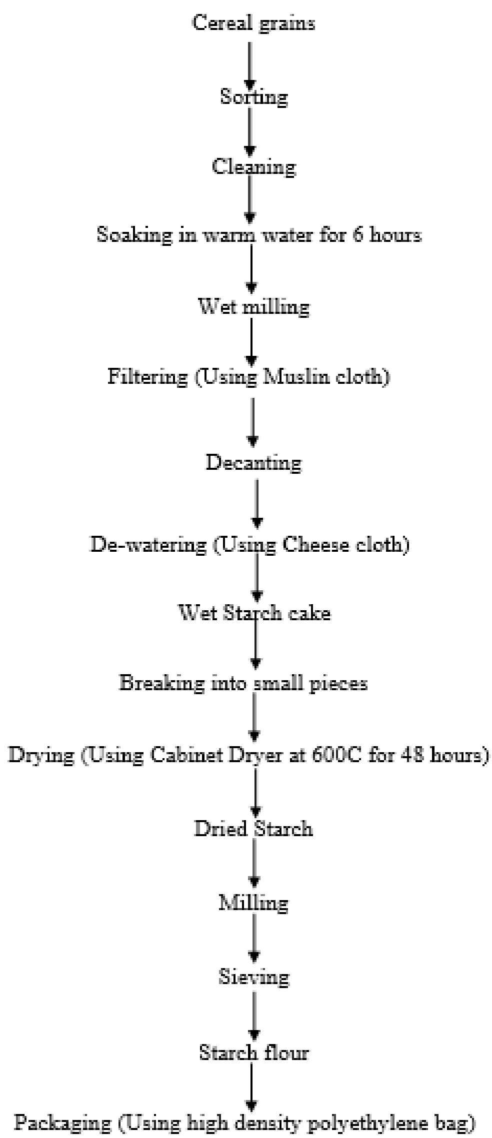
Materials and Methods

Source of Materials

Three (3) varieties of corn viz white, yellow and popcorn were purchased from a local market in Ilaro, Yewa South Local Government of Ogun State. The grains were sorted. The grains (corn) were carefully sorted, cleaned to remove sticks, husks, and stones cobs, damaged and unwanted seeds. These were achieved through winnowing, sieving and hand picking. The cleaned grains were then kept in high density polyethylene bags to avoid moisture uptake and re-contamination before use. All reagents used are of analytical grades.

Production of corn starch flour

Starch was extracted from corn grain according to the procedure of Singh *et al*. (2009) [8] with little modification, the corn grains were soaked in warm water (25^0C) for 6 hours for the softening of the seed coats, endosperm and germ. The corn grains were then wet milled using attrition mill into smooth paste and mixed with water (at a ratio of 1:5). Filtration of the milled grains was effected through the use of muslin cloth after which it was allowed to settle. The supernatant was decanted and the sediment was dewatered with cheese cloth and the starch residue washed three times with clean water. The starch cake obtained after dewatering process was broken, spread thinly on trays and dried in a cabinet dryer at 60^0C for 8 hours. The dried starch samples were milled using milling machine and then sieved through a mesh sieve (British Standard Screens) with 0.33nm diameter. They were then packaged in high density polyethylene bags prior to further analyses



***Source*:** Singh *et al*. (2009) [8].

Fig 1: Flow Chart for the Production of Starch Flour from Corn grain.

Functional properties of corn starch flours

The functional properties carried out on the corn starch were water absorption capacity (WAC), Swelling power (SP), Solubility Index (SI), Viscousity (V) and Turbidity (T).

Water Absorption Capacity; water absorption capacity of the flour samples were determined using method described by Abbey and Ibey (1988) [9] with slight modification. One gram of flour sample was mixed with 10mls of distilled water, placed in a centrifuge tube. The suspension was agitated for 1 hour on a griffin flask shaker after which it was centrifuged for 15 minutes at 22, 00rpm. The volume of water on the sediment was measured. Water absorption capacity was calculated as ml of water absorbed per gram of lour.

Swelling Power and Solubility: The method described by Oladele and Aina (2009) [10] was used to determine both the swelling power and solubility index. One gram of the flour sample was mixed with 10ml distilled water in a centrifuge, heated at 80^0C for 30 minutes. This was continuously shaken during the heating period. The tube was removed from the bath, wiped dry, cooled to room temperature (28^0C) and centrifuged for 15 minutes at 2200rpm. The supernatant was then evaporated and the residue weighed to determine the solubility. The swollen sample (paste) obtained from decanting supernatant was also weighed to determine the swelling power

Swelling power was calculated as weight of the paste/ weight of dry sample

$$\text{Swelling power} = \frac{\text{weight of the paste}}{\text{Weight of dry sample}}$$

Turbidity: The turbidity of starch flour from each corn variety was determined using method described by Perera and Hoover (1999) [11]. A 1% aqueous suspension of starch from each corn variety was heated in water bath at 90oc for 1 hour with constant stirring. The starch paste was then cooled for 1i/2 hour at 30oc. The samples were stored for 5 days at 4oc. The turbidity was determined every 24 hours by measuring absorbance at 640nm against a water blank with spectrophotometer.

Pasting properties of corn starch flour

This was determined using a Rapid Visco Analyser (RVA) (Feemaster Perten N103802 Australia) as described by Li and reported by Akoja and Coker, 2018. About 3.5g of the samples was weighed into the test canister. Then 2.5g of flour sample was weighed into a dried empty canister., 25ml of distilled water was dispensed into the canister containing the sample. The solution was thoroughly mixed and the canister was well filled into the RVA, as recommende. The slurry was heated from 50-90oc with a holding time of 2 minutes followed by cooling to 50oc with 2 minutes holding time. The rate of heating and cooling were at constant rate of 11.25oc/ minute. Peak viscousty/trough breakdown, final viscousity, set back, peak time and pasting temperature were read from the pasting profile with the aid of Thermocline for Windows Software connected to a computer

Results and Discussion
Results

Table 1: The functional properties of three corn starch flour

Samples Parameters				
	Water Absorption Capacity (g/ml)	**Swelling Power (g/ml)**	**Solubility Index (%)**	**Turbidity (NTU)**
White Corn Starch	2.11±0.01 [a]	11.50±0.7 [b]	4.12±0.01 [b]	3.15±0.04 [c]
Yellow Corn Starch	1.98±0.02 [b]	8.70±0.42 [c]	5.28±0.04 [a]	4.65±0.02 [b]
Pop Corn Starch	2.32±0.02 [a]	15.00±0.01 [a]	3.89±0.04 [c]	5.17±0.01 [a]

Values were means ± standard deviation of duplicate determinations. Values with similar letters in the same column do not differ significantly ($p<0.05$)

Table 2: The pasting properties of three corn starch flours

Samples Parameters							
	Peak (cp)	**Trough (cp)**	**Breakdown (cp)**	**Setback (cp)**	**Final visc (cp)**	**Peak time**	**PastingT (oc)**
White Corn Starch	2760.00±15.56 [a]	1836.00±69.29 [b]	924.00±5374 [a]	1074.00±38.18 [b]	2910.00±31.11 [b]	5.43±0.05 [a]	75.80±1.20 [b]
Yellow Corn Starch	2603.00 ±183.85 [b]	1877.00±69.29 [a]	726.00±114.55 [b]	1215.00±196.58 [a]	3095.00±265.87 [a]	5.53±0.09 [a]	78.23±0.11 [a]
Pop Corn Starch	2236.50±14.85 [c]	1544.00±32.53 [c]	629.50±47.38 [c]	1099.00±97.58 [b]	2643.00±65.05 [c]	5.33±0.09 [b]	78.28±0.04 [a]

Values were means± standard deviation of duplicate determination

Discussion
The results of the functional properties of corn starch flours are presented in Table 1. Water absorption capacities of 2.11g/ml,1.98g/ml and 2.32g/ml were obtained for white corn starch flour, yellow corn starch flour and pop corn starch flour respectively. The water absorption capacity represents the ability of a product to associate with water under conditions where water is limited. The amount of water associated with starch granules influences the swelling characteristics of the granules (Singh, 2001). The amount of water absorbed depends primarily on the availability of two types of amydrophilic groups which are capable of binding water through bond formation. These are the polar chains and the carboxyl imido group of peptide bonds (Crosbie, 2004). Water absorption capacity of flour is an indication of the amount of water available for gelatinization and a useful indication of whether protein can be incorporated with aqueous food formulations especially those involving dough handling such as processed cheese, sausages and bread.(Edema *et al*., 2005., Osungbara *et al*., 2010) [15].

Appiah *et al*. (2010) recorded water absorption capacities of 1.89, 2.15 and 2.13g/mi for Nhyria, Tona and Adom cowpea varieties while Adebowale *et al*. (2005) [17] reported water absorption capacities ranging from 1.20 to2.00g/g for full fat and 1.40 to 2.20g/g for defatted in six mucura apecies in Nigeria in a similar work.

The swelling power is the ability of flours to increase in volume when foamed. Swelling power ranged from 8.70g/g to 15.00g/g for the corn starch flours under consideration, indicating significant differences among samples. ($p<0.05$). The extent of swelling depends on the temperature, availability of water, species of starch, extent of starch damage due to thermal and mechanical processes and other carbohydrates and protein such as pectins, hemicelluloses and celluloses. (Crosbie, 2004). Sunday power is regarded in quality criterion in some good formulations such as bakery products and it is an evidence of non-covalent bonding between molecules within starch granules and also a factor in the ratio of amylose and amylopectin (Onitilo *et al*., 2007). Swelling power has been related to the associative binding within the starch granule and apparently the strength and character of the nuclear network is also related to the amylose content of the starch with low amylose content leading to swelling power (Adebowale *et al*., 2005) [17]. The swelling power obtained in this work is in contrast to those reported by Appiah *et al*. (2011) [18] where Tona has 2.65%, Nhira; 2.66% and Adom; 2.68%. however, flours generally gives high swelling power values, suggesting that they are useful in food systems where swelling is required.

Solubility in terms of 4.12%, 5.28% and 3.89% were obtained for white corn starch flour, yellow corn starch flour and pop corn starch flour respectively. According to Ikegu *et al*, (2010), solubility is indicative of water penetration ability into starch granules of flours. Solubility index also provides the evidence of interactions between the water molecules and the starch chains in the crystalline and amorphous region. There were significant differences ($p<0.05$) in values obtained.

Pasting Properties
The results of the pasting properties of corn starch flours are presented in Table 2. Peak viscousity is the maximum attainable viscousity during heating, it also indicate the water binding capacity of the starch. Peak viscousities of 2760.00, 2603.00 and 2236.50 cP were obtained for white corn starch flour, yellow corn starch flour and pop corn starch flour respectively. It was observed that white corn starch flour has the highest peak viscousity with popcorn starch flour having the least. Ji *et al*., (2003) [2] had reported peak viscousity in the range of 152 and 222 for selected corn line. Though viscousity is the maximum viscousity of constant temperature phase of rapid visco analyzer profile, the ability of the phase to withstand breakdown depend on cooling. Though viscousity ranged from 1544-1877 for the three corn starch flour samples. Of all the three corn starch samples, pop corn starch flour showed the least viscousity; indicating significant differences ($p<0.05$) in the three samples.

The breakdown is the difference between the peak and the tough visousity which is an indication of the rate of gelling stability which is dependent on nature of the product (Adegunwa *et al*., 2015) [21]. The breakdown viscousity, which is a measure of cooked starch to disintegration ranged from 692.50-924.00 for the corn starch flour sample. It was observed that there are significant differences ($p<0.05$) in breakdown viscousity, probably due to agglutination of starch components of amylose and amylopectin.

The set back region in the phase on the pasting curve after cooling the sample to 50%. It is the phase where re-trogradation of starch molecules occurs. High setback value is known to be associated with a cohesive paste, while a low value indicates that the phase is not cohesive with less tendency to retrograde upon cooling.

Set back viscousity, which measures the synacresis of starch upon cooking of the starch pastes are 1074, 1215cP and 1099cP respectively for the three corn starch flour, indicating significant differences ($p<0.05$) among samples. The final viscousity which indicates the ability of the starch to form a viscous paste varied from 2643-3095 for the samples. Miles *et al*. (1985) [23] reported increases in final viscousity might be due to the aggregation of the amylose molecules. Peak time of 5.43mm, 5,53mm and 5.33mm were obtained for all the samples respectively showing significant difference ($p<0.05$) among treatments. Peak time is indicative of ease of cooking a particular sample. According to literature, high peak time has been reported for wheat flour which can be attributed to the high degree of swelling of wheat starch granules. (Erickson *et al*, 2014, Akoja, 2018) [13].

The pasting temperature (temperature at the onset of rise in viscousity) for various corn starch flour ranged from 75.80^0C-78.25^0C. The high pasting temperatures exhibited by both white corn starch flour and yellow corn starch flour is an indication of their resistance towards swelling. In a similar work, Sectharaman *et al*. (2001) had reported pasting temperatures in the range of 74.9^0C-84.7^0C for Argentinean corn landraces. Also reported was the fact that pasting properties of starch depends on the rigidity of starch granule, which in turn affect the granule swelling potential and amount of amylose leaching out in the solution (Morris, 2000) [23].

Conclusion

Generally, corn starch serves as a weaning foods for infants and provide dietary staples for teaming adults all over the world. The functional and pasting properties of three (3) corn starch flours evaluated in this research work will no doubt be useful to food processors in selecting the appropriate variety for end use suitability since other attributes were measured apart from nutritional contents of the starches.

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