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Soaking and Drying Effect on the Functional Properties of Ogi Produce from Some Selected Maize Varieties

Bolaji O.T.*, Oyewo A.O, Adepoju P.A

Department of Food Technology Ikorodu Lagos Lagos State Polytechnic
*Corresponding author: olusholat@yahoo.com

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Abstract This study evaluated the effect of soaking period (12, 24 and 36 hours) and drying temperature (40,50 and 60°C) on the functional properties of Ogi powder produced from four different maize varieties; A5W, A4Y, D1Y and S7Y. The moisture content and drying rate decreased significantly ($p < 0.05$) with increase in time and drying temperature. There were no significant difference ($p > 0.05$) in Bulk Density, Sedimentation and Swelling Power. The result revealed that sedimentation volumes were not influenced by processing methods while starch damage of the Ogi powders varies from 92.03 to 95.02%. This increased with increase in drying temperature. Ogi powders had least gelation of 8% for all the maize varieties. There were significant differences ($p < 0.05$) in Viscosity, Solubility, Water Absorption Capacities (WAC) and Oil Absorption Capacities (OAC). Ogi powder produced from A4Y variety and soaked for 12 hours exhibited higher WAC values at 50°C. This variety also displayed higher values of water absorption capacity at all temperatures. Solubility, viscosity and swelling power increased with increase in temperature. The viscosity of the Ogi powders pastes ranged from 1200-1794 cps, and 804- 1540 at 80 and 30°C, respectively. Ogi powders produced from D1Y and S7Y exhibited higher degree of retrogradation. Differences observed in the functional properties among varieties highlight the possible application of end-product suitability in Ogi powder processing.

Keywords: *Ogi, Maize, soaking, drying, viscosities, functional properties*

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1. Introduction

Ogi is a common weaning food or adult gruel produced from cereals like Sorghum, Maize and Millet). Ogi is a popular breakfast cereal and infant weaning food in Nigeria (Banigo and Muller, 1972; Odunfa, 1985; Okoruwa, 1997). The wet Ogi can be boiled at 8-10% total solids into a porridge or pap which serves as weaning food for infants, breakfast for children and convenient meal (Onyekwere *et al.*, 1989). It is also known as 'Eko', 'Agidi', 'Akamu', and 'Koko' in Nigeria. The traditional production process involves soaking of maize grains in cold water for 1-3 days after which the water is decanted (Akinrele, 1970; Odunfa and Adeyele, 1985; Ohenhen and Ikenebomeh, 2007). The soaked grains are wet milled and sieved using muslin cloth and the filtrate is fermented for 2-3 days to yield wet Ogi, which is a sour, starchy sediment (Akinrele, 1970; Odunfa and Adeyele, 1985; Ohenhen and Ikenebomeh, 2007). The physical and biochemical qualities of Ogi were reported to be influenced by the type of cereal grain, fermentation or souring periods and the milling method (Banigo and Muller, 1972; Akingbala, 1981; Osungbaro, 1990). Aderiye and Laleye (2003) reported that Ogi is a very important food to the rural communities in Southern Nigeria. According to these researchers, Garri and Ogi were the most frequently consumed fermented foods in that area. Also, Ajayi (2004) showed that cereal grain processing industries, using maize as their raw material to produce Ogi, constituted about 11.19% of the total food processing industries in rural Oyo State, Nigeria (Ajayi, 2004).

Many researchers have reported factors affecting the textural quality of Ogi porridge. These include the type of cereal grains, variety, milling technique; particle sizes; steeping and fermentation periods (Amoa and Muller, 1976; Klaus and Hinz, 1976; Adeyemi, 1983; Adeyemi and Beckley, 1986; Osungbaro, 1990a; Osungbaro 1990b). Ogi had been successfully prepared using dry milled sorghum and maize flours (Umoh and Fields, 1981; Adeyemi, 1983; Osungbaro, 1990a). The dry milling was considered more convenient than wet milling process, since the flour could be dispensed and packaged to consumers for subsequent steeping and fermentation. Drying Ogi will aid ease of fortification and shelf life (Edema *et al.*, 2005; Fasasi *et al.*, 2007; Otunola *et al.*, 2006; Aminigo and Akingbala, 2004).

It is with the understanding of the importance of drying reported for Ogi that the investigation into the processing conditions (soaking and drying) on the functional properties was conducted. This study was undertaken to unravel the unique characteristics of Ogi Powder as may be affected by process conditions (soaking and drying temperature). This have the potential of determining possible application of end-product suitability in Ogi powder processing.

2. Materials and Methodology

Four maize varieties (A4Y, A5W, S7Y, D1Y) as shown in Table 1 used in this study were obtained from the institute of Agricultural Research and Training in Ibadan, Oyo state. The maize grains were thoroughly cleaned and foreign materials carefully removed. Samples were soaked at varying time of 12, 24 and 36 hours, respectively at a room temperature. This was subsequently decanted and wet milled with attrition milling machine model M230 and sieved with muslin cloth. The water was squeezed out manually and dried at temperature of 40, 50 and 60°C using Genlab drying cabinet model DC125. The dried samples were pulverized using laboratory mill IKA model M20 and sieved through 212 µm mesh. The samples were packaged in polyethylene bag and stored at ambient temperature for further analysis. All the analysis was replicated and data obtained were subjected to statistical analysis.

Table 1. Codes four varieties of maize

A4Y	ART/98/SW1 – Y
A5W	ART/98/SW5 – OB –W
S7Y	SUWAN 1 SR. Y
D1Y	DMR LSR. Y

2.1. Determination of Moisture Content

Two gram (2g) of each sample was measured into a previously weight crucible and transferred into the oven set at 105°C to dry over overnight. The crucible plus sample was removed from the oven and transferred into desiccators cooled for 60 minutes and weighed (AOAC, 2005). The moisture content was computed using standard mathematical relationship.

2.1.1. Bulk Density (BD)

The procedure of Narayana and Narasinga, (1984) was used with slight modification. A specified amount of the powdered Ogi was put into an already weighed (W) 25ml measuring cylinder, it was gently tapped and the volume was noted. The new level of sample on measuring cylinder was recorded in ml as (M).The bulk density was computed as shown in Equation (1)

$$BULKDENSITY = \frac{W}{M} \qquad (1)$$

2.1.2. Water and Oil Absorption Capacity (WAC and OAC)

The water absorption capacity of each Ogi flour sample was determined using the method of Sathe *et al.*, (1982). A suspension of 1g of powdered Ogi (db) in 10ml of distilled water or [10ml of executive chef oil with density of 0.92g/ml. The suspensions were stirred for 5minutes using magnetic stirrer (staurt co ltd 7664) at 1000rpm. The mixture was then transferred into centrifuge (CENCOM SELECTA) for 30 minutes at 3500rpm. The free water or oil obtained was removed carefully and the volume of the water /oil was determined. The water or oil absorbed by the powdered Ogi was calculated as the difference between the initial water/oil used and the volume of the supernatant obtained after centrifuging. The result was expressed as a gram of water or oil absorbed per gram of sample.

2.1.3. Sedimentation Volume

Sedimentation volume was determined according to the procedure of Raja *et al.* (1987). A 10g (db) of Ogi powdered was weighted into a graduated 100 ml measuring cylinder followed by addition of 100ml distilled water. The content was mixed thoroughly. The sediment volume was recorded after 3 hours when the level became constant.

2.1.4. Swelling Power and Starch Solubility

The swelling power and solubility of the Ogi samples were determined using the method reported by Leach *et al.* (1959). A 1g of Ogi powered (db) was weighed into centrifuge tube and 50ml distilled water was added. These tubes were immersed in water bath at temperature range from 50 to 90 °C at 10 °C intervals for 30 minutes, thoroughly and constantly stirred with glass rod during the heating period. The tubes were removed, cooled to room temperature and centrifuged at 5000 rpm for 15 minutes. The supernatant was fully transferred into a conical flask and 5ml was pipetted into a weighed petri dish, evaporated over a steam bath and dried in the air oven at 105°C for 4 hours. The weight of the pastes were determined and used to calculate the swelling power as gram of sediment paste per gram starch. Percentage solubility was calculated as gram of soluble starch per gram starch.

2.2. Viscosity Measurement

The viscosity of different Ogi powder samples with control were measured in triplicates at controlled temperature of 80°C for hot paste and 30°C for the cold paste using a digital rotational Brookfield viscometer (Brookfield Viscometer DV-11+Pro, RVDV-11+P Model). Their readings were taken after 1 min rotation at speed (100 rpm). Spindle #4 hot paste and #6 for cold paste was used for all measurements. A 600 ml beaker was used for the measurement with the viscometer guard leg on. The samples were poured into the beaker to reach a level that covers the immersion groove on the spindle shaft. All viscosity measurements were carried out immediately after preparing the Ogi powder.

2.2.1. Least Gelation Concentration

The method of Coffman and Garcia (1977) was used. Appropriate sample suspensions of 2, 4, 6, 8, 10, 12, 14, 16, 18% (m/v) were prepared in 5cm^3 distilled water. The test tube containing these suspensions were heated for 1 hour in boiling water followed by rapid cooling using chilled water at 4°C for 1 hour. The least gelation concentration was taken as the concentration when the sample from inverted test tube did not fall down or slip.

2.2.2. Starch Damage

One gram of Ogi powder was weighed and placed in the SDmatic spoon. A 3 grams each of boric acid (H_3BO_3)

and potassium iodide (KI) and 1 drop of sodium thiosulphate ($Na_2O_3S_2$) at 0.1mol/l were prepared in a plastic bowl and then pour into SDmatic reaction bowl. The moisture and protein content of sample were input into the equipment before the test cycle initiated. Readings were taken after the test cycle is completed and results were recorded (AACC, 2005).

3. Statistical Analysis

All determinations of this research work were carried out in triplicates; errors were calculated as standard errors from the mean. The data obtained were subjected to statistical analysis and analysis of variance was determined using SPSS16. Where significant difference ($p<0.05$) existed, means were separated using Duncan's multiple range tests..

4. Results and Discussion

The moisture content of the Ogi produced from the four varieties of maize decreased significantly ($p<0.05$) with increase in drying time. The results revealed that there was significant decrease in moisture content with increase in the drying tempertaure. The decrease in moisture content and drying rate (Figure 1) were non linear with increase in the drying period and Drying temperature. This may be connected with the migration of water within the Ogi and evaporation of moisture from Ogi into the air. It was observed that the total drying time decreased with increase drying temperature. Similar results have been reported in the literature for various fruits and vegetables such as Sacilik et al. (2005) for organic tomato and Yaldiz et al. (2001) for sultana grapes.

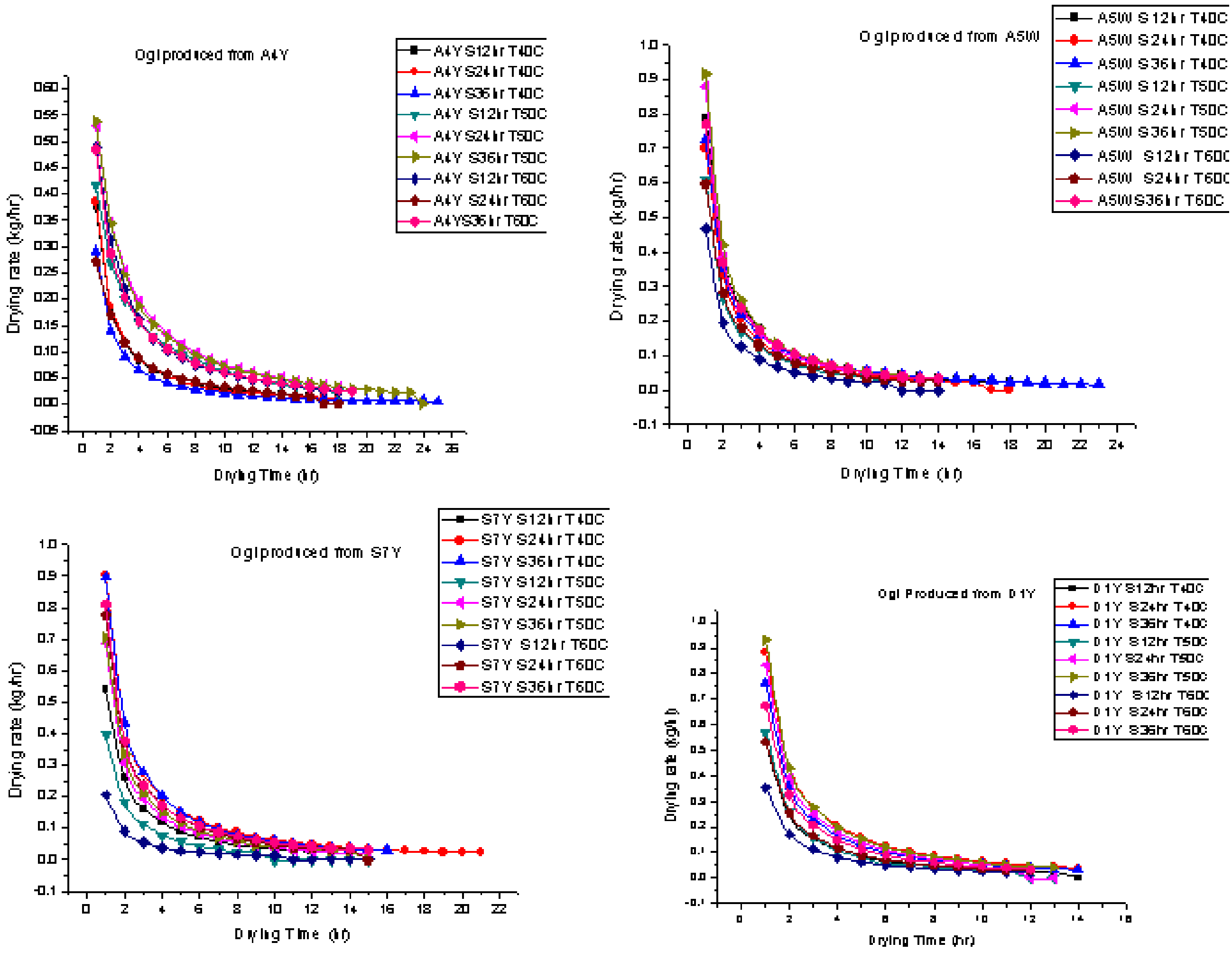

Figure 1. Drying rate of Ogi produced from four varieties of maize and dried at varying temperature

4.1. Bulk Density

The bulk density of Ogi powders from the maize varieties is as shown in Table 2. The value ranged between 0.625 and 0.678g/ml with mean values of 0.6684g/ml, 0.6377g/ml, 0.6651g/ml and 0.6569g/ml for A5W, A4Y, D1Y and S7Y, respectively. These were comparable with the values reported by (Okoruwa, 1997; Edema, 1998; Adegunwa *et al.*, 2011) however lower compared to durum wheat blends (Amajeet *et al.*, 1993). The bulk density values were functions of both the density of powder particles and the spatial arrangement of particles in the powder bed (International pharmacopeia, 2012).) The decrease in bulk density may help in reduction of transportation and packaging cost. According to this research work, soaking period and drying time did not indicate any significant effect on the bulk densities of the Ogi powders and there was no significant difference ($p<0.05$) in the bulk densities.

Table 2. Effect of soaking time and drying temperature on some functional properties Ogi

sample	soaking Time (hour)	Drying Temperature (°C)	Bulk density (g/ml)	sedimentation volume (ml)	Water absorption capacity(g/g)	Oil Absorption capacity(g/g)
A4Y	12	40	0.635[a]	30[c]	2.0[b]	0.8
		50	0.635[a]	31[c]	2.75[c]	0.92
		60	0.646[a]	30[c]	2.0[ab]	1.0
	24	40	0.625[a]	30[c]	2.5[b]	0.81
		50	0.625[a]	31[c]	2.25[b]	0.81
		60	0.625[a]	29[bc]	1.5	0.94
	36	40	0.646[ab]	30[c]	2.25	0.82
		50	0.646[ab]	31[c]	2.0[b]	0.8
		60	0.646[ab]	29[bc]	1.0[a]	0.94
A5W	12	40	0.667[b]	30[c]	1.0[a]	0.87
		50	0.667[b]	28[ab]	1.25[ab]	0.89
		60	0.667[b]	28[ab]	1.5[ab]	1.01
	24	40	0.667[b]	27[a]	1.0[a]	1.0
		50	0.669[b]	27[a]	1.25[ab]	1.0
		60	0.667[b]	29[bc]	1.5[ab]	1.0
	36	40	0.636[a]	28[ab]	1.25[ab]	0.86
		50	0.657$_{ab}$	30[c]	1.5[ab]	0.82
		60	0.679[b]	28[ab]	1.0[a]	0.89
S7Y	12	40	0.646[ab]	28[ab]	1.2[a]	0.9
		50	0.667[b]	27[a]	1.4[ab]	0.92
		60	0.874[c]	29[bc]	1.4[ab]	1.05
	24	40	0.635[a]	28[ab]	1.2[a]	0.8
		50	0.655[ab]	28[ab]	1.2[a]	0.84
		60	0.662[b]	29[bc]	1.4[ab]	0.92
	36	40	0.646[ab]	29[bc]	1.4[ab]	0.81
		50	0.655[ab]	28.5[ab]	1.2[ab]	0.81
		60	0.667[b]	29[ab]	1.4[ab]	0.86
D1Y	12	40	0.657[ab]	30[c]	1.4[ab]	0.84
		50	0.667[b]	28[ab]	1.8[b]	0.89
		60	0.677[b]	26[a]	1.4[ab]	1.05
	24	40	0.667[b]	28[ab]	1.6[ab]	0.81
		50	0.659[b]	27[a]	1.2[a]	0.97
		60	0.668[b]	28[ab]	1.4[ab]	0.99
	36	40	0.646[ab]	27[a]	1.4[ab]	0.92
		50	0.667	28[b]	1.2[a]	0.98
		60	0.678	28.5[ab]	1.2	1

4.2. Sedimentation

Sedimentation is an important determinant of cooking quality. This is shown in Table 2. The grains with good hydration and lower cooking time are generally preferred for cooking purposes (Ahenkora *et al.*, 1999). The value ranged between 26 and 31 ml. Okaka and Potter, (1979) reported that sedimentation and hydration of maize is influenced by processing methods affecting starch gelatinization and swelling power. However, in the present investigation the same tendency was observed however, there was no significant difference ($p > 0.05$).

4.3. Water Absorption Capacity (WAC) and Oil Absorption Capacity (OAC)

The result for water absorption capacity (WAC) is as shown in Table 2. The results of Water Absorption Capacity (WAC) and Oil absorption capacity of Ogi samples which ranged between 1.0g/g and 2.75g/g. There were significant differences ($p < 0.05$) between the maize varieties. The variations in WAC values also indicated differences in the degree of engagement to form hydrogen and covalent bonds between starch chains and the degree of availability of water binding sites among the starches (Hoover and Sosulski, 1986). Similar results were reported for yellow and white maize varieties (Adegunwa *et al.*, 2011). The water absorption capacity of the Ogi powder gave it an advantage of being used as a thickener in liquid and semi-liquids foods since the flours has the ability to absorb water and swell for improved consistency in food. The observed differences in WAC of the starches might also be due to various factors such as particle size, amylose/amylopectin ratio and molecular structure (Adegunwa *et al.*, 2011). The larger the granular size of powder has may affect the water binding capacity of starches (Akalu *et al*., 1998).

Oil absorption capacity (OAC) is the ability of the flour protein to physically bind fat by capillary attraction and it is of great importance since fat acts as flavor retainer and increase the mouth feel of foods (Kinsella, 1976). OAC of the Ogi powder ranged between 0.8 to1.05g/g with significant difference ($p < 0.05$) among the maize varieties. These values were lower than OAC of taro flours - 190%(Tagodoe and Nip, 1994), lupin seed flour, 167% (Sathe *et al.*, 1982b). Protein denaturation and dissociation may occur during fermentation which exposes the polar amino acid of the maize proteins thus enhancing hydrophobicity of protein (Vausinas and Nakai, 1983). These observations were consistent with the reports of Sefa-Dedeh *et al.* (2002). There was no clear trends in WAC and OAC values for Ogi powder. However, Ogi powder from A4Y soaked for 12 hours exhibited higher WAC values at 50°C compared with others.

4.4. Swelling power and Solubility

Swelling is a function of ratio of amylose to amylopectin, the characteristics of each fraction in terms of molecular weight - distribution degree length of branching and confirmation (Onitilo, 2007). The results of swelling power and solubility of the Ogi powder at different temperatures are presented in Table 3 and Table 4, respectively. The swelling power of the starches increased with increase in temperature. The swelling power of the Ogi powder at 50, 70 and 90°C ranged from 2.32 to 3.78, 7.01- 8.43 and 11.67- 14.58 g/g, respectively. The results were similar to the report by Adebowale *et al*. (2005) for red sorghum flour and legume starches by Hoover and Sosulki, (1991). This may have been as a result of fallen gelatinization temperature of Ogi powders. The swelling pattern of the flour suggests the level of crystalline packing of the starch granules (Billiadaris, 1982). This indicated that the swelling power granules reflect the extent of the association forces within the granules. A decrease in solubility was noticed in all samples as the temperature increases. Since leaching of amylose is said to be responsible for most of the solubility of starch based product (Dengate, 1981), higher solubility in S7Y implies that it is greater in leaching than other. According to Numfor *et al*.(1996), leaching is enhanced by hydrolysis of amylose during soaking or hindered by new internal bounding. Solubility of Ogi powered may be a function of processing and reconstitution. The higher the solubility, the more the Ogi may reconstitute well in water.

Table 3. Effect of soaking time and drying temperature on swelling power Ogi

						SWELLING POWER (g/g)	
SAMPLE	**SOAKING TIME (hrs)**	**DRYING TEMPERATURE (°C)**	**50 (°C)**	**60 (°C)**	**70 (°C)**	**80 (°C)**	**90 (°C)**
A4Y	12/40C	40	3.25^{i}	4.098^{g}	7.46^{e}	10.59^{c}	14.579a
		50	3.16^{i}	4.11^{g}	6.947^{ef}	9.342^{d}	12.498^{bc}
		60	3.12^{i}	4.13^{g}	8.06^{e}	9.476^{d}	11.965^{bc}
	24	40	2.93^{ij}	3.87^{gh}	7.17^{ef}	9.987^{cd}	13.59^{a}
		50	2.89^{ij}	3.98^{gh}	7.232^{e}	10.07^{dc}	14.269^{a}
		60	3.26^{i}	4.49^{g}	7.213^{e}	9.332^{d}	11.037^{bc}
	36	40	2.546^{ij}	3.99^{gh}	7.29^{e}	9.287^{d}	13.709^{ab}
		50	2.591^{ij}	4.10^{gh}	7.625^{e}	10.49^{bc}	15.29^{a}
		60	3.097^{i}	4.12^{g}	7.955^{e}	9.765^{d}	12.42^{b}
A5W	12	40	3.275^{i}	4.32^{g}	8.43^{de}	9.52^{d}	12.35^{b}
		50	3.459^{i}	3.26^{i}	7.08^{ef}	9.56^{d}	12.56^{b}
		60	2.876^{ij}	3.25^{i}	7.01^{ef}	9.19^{de}	12.48^{b}
	24	40	3.098^{i}	3.83$^{g g}$	8.06^{e}	9.67^{d}	12.25^{b}
		50	2.852^{ij}	3.15^{hi}	7.03^{ef}	9.73^{d}	12.8^{b}
		60	2.99^{i}	3.149^{hi}	7.21^{e}	9.99^{dc}	13.39^{ab}
	36	40	3.034^{i}	3.96^{gh}	8.04^{e}	9.326	12.749^{b}
		50	3.301^{i}	3.02^{hi}	7.08^{ef}	8.981^{de}	12.15^{b}
		60	3.272^{i}	3.03^{hi}	7.26^{e}	9.378^{d}	12.47^{b}
S7Y	12	40	3.223^{i}	4.09^{g}	7.46^{e}	10.35^{c}	14.57^{a}
		50	3.235^{i}	4.11^{g}	6.95^{ef}	9.663^{d}	12.47^{b}
		60	3.12^{i}	4.12^{g}	8.06^{e}	9.482^{d}	11.99^{bc}
	24	40	3.128^{i}	3.87^{gh}	7.18^{ef}	9.978^{d}	13.59^{ab}
		50	2.89^{ij}	3.982^{g}	7.23^{e}	10.01^{cd}	14.24^{ab}
		60	3.26^{i}	4.49^{g}	7.21^{e}	9.39^{d}	11.67^{bc}
	36	40	2.443^{k}	3.95^{g}	7.93^{e}	9.322^{d}	13.687^{ab}
		50	2.321^{k}	4.10^{g}	7.61^{e}	10.41^{d}	15.40^{a}
		60	3.216^{i}	4.12^{g}	7.89^{e}	9.76^{d}	12.248^{b}
D1Y	12	40	3.275^{i}	4.326^{g}	8.43^{e}	9.45^{d}	12.36^{b}
		50	3.459^{i}	3.262^{i}	7.01^{ef}	9.53^{d}	12.53^{b}
		60	2.876^{ij}	3.515^{hi}	7.22^{e}	9.36^{d}	12.51^{b}
	24	40	3.098^{i}	3.654^{hi}	8.06^{e}	9.67^{d}	12.33^{b}
		50	2.857^{ij}	3.059^{i}	7.04^{ef}	9.72^{d}	12.51^{b}
		60	2.99^{ij}	3.13^{i}	7.413^{e}	9.94^{cd}	13.13^{b}
	36	40	3.784^{hi}	4.16^{g}	8.034^{e}	9.42^{d}	12.67^{b}
		50	3.301^{i}	3.02^{i}	7.734^{e}	8.951^{d}	12.25^{b}
		60	3.27^{i}	3.03^{i}	7.204^{e}	9.376^{d}	11.98^{bc}

According to Osungbaro (1990a), the degree of swelling and amount of soluble components depends on the type and species of starch in the flour samples. According to Hoover and Martin (1991) and Hoover and Maunal (1996), increase in temperature may allow amylose (water soluble fraction) molecules located in the bulk amorphous regions to interact with the branched segment of amylopectin (water-insoluble fraction) in the crystalline regions and thereby weakens the starch granules of flour leading to improved solubility. The solubility of Ogi powders decreased consistently with increase in temperatures. The decrease in solubility was highest at 90°C. This may be due to the effect of swelling which has form matrixes around the leached amylase (Hoover and Martin, 1991). The differences among the Ogi powder samples in their swelling and solubility patterns can form the basis of the functional properties that determine their suitability in product development.

Table 4. Effect of soaking time and drying temperature on Solubility of Ogi

						SOLUBILITY (g/g)	
SAMPLE	**SOAKING TIME (hrs)**	**DRYING TEMPERATURE (°C)**	**50 (°C)**	**60 (°C)**	**70 (°C)**	**80 (°C)**	**90 (°C)**
A4Y	12	40	0.235^{d}	0.101^{c}	0.073^{cb}	0.054^{a}	0.038^{a}
		50	0.253^{d}	0.214^{d}	0.103^{bc}	0.099^{ab}	0.019^{a}
		60	0.22^{d}	0.215^{d}	0.198^{cd}	0.045	0.087^{ab}
	24	40	0.248^{d}	0.223^{d}	0.183^{c}	0.067	0.066^{ab}
		50	0.249^{d}	0.198^{cd}	0.172^{c}	0.09	0.036^{a}
		60	0.196^{cd}	0.243^{d}	0.11^{c}	0.076	0.022^{a}
	36	40	0.349^{f}	0.277^{e}	0.154^{c}	0.052	0.022^{a}
		50	0.219^{d}	0.1^{ab}	0.063	0.057	0.02^{a}
		60	0.216^{d}	0.209^{d}	0.181^{c}	0.087	0.031^{a}
A5W	12	40	0.206^{cd}	0.197^{cd}	0.165^{c}	0.088^{ab}	0.033^{a}
		50	0.302^{ef}	0.217^{d}	0.133^{c}	0.088^{ab}	0.015^{a}
		60	0.502^{h}	0.226^{d}	0.158^{c}	0.072^{ab}	0.022^{a}
	24	40	0.383^{e}	0.339^{e}	0.161^{c}	0.078^{ab}	0.022^{a}
		50	0.529^{g}	0.206^{cd}	0.153^{c}	0.076^{ab}	0.022^{a}
		60	0.429^{g}	0.222	0.143	0.056^{a}	0.020^{a}
	36	40	0.207^{d}	0.287^{d}	0.172^{c}	0.091^{bc}	0.051^{a}
		50	0.301^{e}	0.215^{cd}	0.209	0.10^{c}	0.043^{a}
		60	0.301^{e}	0.198^{cd}	0.153^{c}	0.089	0.041^{a}
S7Y	12	40	0.204^{d}	0.20^{cd}	0.122^{c}	0.045^{a}	0.01
		50	0.387^{f}	0.311^{e}	0.219^{cd}	0.115^{c}	0.078
		60	0.396^{f}	0.302^{e}	0.279^{d}	0.162^{c}	0.045
	24	40	0.194^{cd}	0.123^{cd}	0.102^{bc}	0.079^{ab}	0.066
		50	0.387^{f}	0.289^{d}	0.199^{cd}	0.103^{cb}	0.055
		60	0.437^{f}	0.314^{e}	0.238^{cd}	0.178^{c}	0.067
	36	40	0.437^{f}	0.332^{e}	0.294	0.162^{c}	0.043
		50	0.289^{e}	0.26^{d}	0.188^{cd}	0.122^{c}	0.054
		60	0.435^{f}	0.376^{e}	0.211^{cd}	0.156^{c}	0.099
D1Y	12	40	0.447^{g}	0.382^{e}	0.265c	0.117^{c}	0.045a
		50	0.387^{e}	0.321^{e}	0.26	0.125^{c}	0.067^{ab}
		60	0.512^{g}	0.399^{ef}	0.302	0.198^{cd}	0.094^{a}
	24	40	0.437^{f}	0.323^{e}	0.285	0.166^{c}	0.073^{a}
		50	0.204^{cd}	0.201^{c}	0.155^{c}	0.07 7^{b}	0.052^{a}
		60	0.467^{g}	0.379^{e}	0.234	0.10^{d}	0.057^{a}
	36	40	0.346^{e}	0.292^{d}	0.201	0.096^{b}	0.086^{ab}
		50	0.294^{d}	0.271	0.199^{cd}	0.078^{b}	0.055^{ab}
		60	0.387^{e}	0.288^{d}	0.255	0.167^{c}	0.097^{ab}

Table 5. Effect of soaking time and drying temperature on Viscosity and starch Damage of Ogi

			VISCOSITY (CPS)		DAMAGE STARCH (AI %)
SAMPLE	**SOAKING TIME (hrs)**	**DRYING TEMPERATURE (°C)**	**80**°C	**30**°C	
A4Y	12	40	1781^{a}	1540^{d}	92.55
		50	1421^{f}	1110^{k}	94.05
		60	1262^{i}	865^{d}	95.02
	24	40	1743^{b}	1590^{d}	92.03
		50	1231^{j}	984^{l}	94.17
		60	1462^{e}	786^{p}	94.76
	36	40	1782^{a}	1470^{f}	92.11
		50	1335^{h}	1192^{cd}	93.21
		60	1254^{h}	950^{m}	93.53
A5W	12	40	1778^{a}	1303^{c}	93.01
		50	1370^{g}	1225^{h}	93.63
		60	1282^{h}	725^{q}	94.50
	24	40	1794^{a}	1310^{h}	92.93
		50	1760^{a}	1110^{k}	93.41
		60	1420^{f}	804^{n}	94.44
	36	40	1773^{a}	1519^{d}	92.35
		50	1739^{b}	1032^{l}	92.59
		60	1392	810^{o}	93.27
S7Y	12	40	1750^{c}	1444^{f}	92.41
		50	1484^{e}	1102^{k}	93.12
		60	1273^{j}	982^{l}	93.78
	24	40	1770^{b}	130g	91.87
		50	1450^{f}	1176^{j}	93.01
		60	1235^{j}	1003^{m}	94.54
	36	40	1792^{a}	1572^{b}	92.85
		50	1498^{e}	1109^{cd}	93.46
		60	1258^{i}	879^{n}	93.89
D1Y	12	40	1763^{b}	1486^{b}	92.16
		50	1403^{f}	1039^{cd}	94.22
		60	1226^{g}	892^{d}	94.07
	24	40	1801^{a}	1600^{c}	92.48
		50	1457^{f}	1251^{i}	94.42
		60	1277^{h}	1068^{m}	94.23
	36	40	1756^{b}	1472^{f}	92.32
		50	1433^{f}	1126^{ck}	93.56
		60	1200j	978^{m}	93.67

The viscosity and starch damage values of the Ogi powder from all the maize varieties pastes is as shown in Table 5 and this ranged from 1200-1794 cps, and 804-1540 at 80 and 30 °C, respectively. The viscosity values of Ogi powder pastes were lower when compared with those of sweet potato and cocoyam starch pastes (Peroni *et al.*, 2006). Ogi powder from S7Y and A5W exhibited higher paste viscosity at 80 °C than their corresponding A4Y and D1Y. There was significant difference ($p<0.05$) in the viscosity of the Ogi powder at both temperature of measurement and soaking time. The viscosity of Ogi powders from S7Y and A5W were similar to those Okoruwa *et al.* (1995) and Fasasi *et al.(*2005). The differences observed in the viscosities of the Ogi powder may be attributed to different rates of water absorption and swelling of starch granules of these flours during heating (Ragaee and Abdel-Aal, 2006). Retrogradation properties of starch paste are often related to the structures of amylose and amylopectin (Peroni *et al.*, 2006; Gudmundsson, 1994). Lower degree of retrogradation may be attributed to higher content of short branches of amylopectin chains and long amylose molecules (Spence and Jane, 1999). According to Sasaki, 2005 retrogradation is a function of strong or weaker crystallinity. Among the Ogi powders, A5W and S7Y which exhibited higher viscosities also, displayed the highest degree of retrogradation (1212cps and 1174cps, respectively). There was no significant differences ($p>0.05$) on the levels of retrogradation for maize varieties. Peroni *et al.* (2006) reported higher levels of retrogradation for ginger and yam starch, canna, sweet potato, arrowroot and cassava starches. The retrograded Ogi powders in this study were within the reported range by Okoruwa *et a.* (1995), Edema (2005) and Fasasi *et al.* (2008). The greater degree of retrogradation in tubers could be attributed to higher contents of short amylopectin branches (Shi and Seib, 1992; Spence and Jane, 1999) unlike the cereals. It was well established that starches with higher enthalpies of gelatinization exhibit lower levels of retrogradation and vice versa.

4.3. Starch Damage

The results showed that the percentage absorbed iodine were high in all varieties irrespective of the soaking time and drying temperature and were above 90% which indicated higher degree of starch damage in all the Ogi powders. The starch damage of the Ogi powders varies from 92.03 to 95.02%. The results obtained were higher than those reported by Bolade (2010), who reported starch damage range of 11.3 to 13.9% for some maize varieties. It was also higher than the starch damage between 73.5 and 75.8% reported by Faridi (1990). The difference in the results may be due to the method in the determination of starch damage. The variation in the damaged starch values of flours from different maize varieties indicated that different maize types could respond differently to the same milling operational procedures. This may be attributed to genetic make-up of endosperm of each maize variety as the bond strength, the starch granules and the embedding protein matrix within the endosperm. This determine varying resistances during milling (Bolade, 2010; Faridi, 1990). The degree of maize kernel hardness is another factor that may be responsible for damaged starch variation in the flours (Faridi, 1990). Faridi (1990) observed that the variation in the damaged starch value of cereal flour was dependent on the severity of the milling process and the hardness of the cereal kernel.

5. Conclusion

The bulk densities and Sedimentation volumes of the Ogi powders were not influenced by processing methods. Water absorption capacity of some Ogi powder significantly increased after drying and increased with increase in temperature. On the contrary, the solubility decreased with increase in temperature. The Starch damage was rather affected by the milling process and not the drying process. Soaking period did not have noticeable significant effect on the functional properties compared with drying temperature.

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