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ORIGINAL ARTICLE

Rheological Properties and Quality Evaluation of Dried Ogi Supplemented with Date Flour as Sugar Substitute

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Abstract

This study was carried out to evaluate rheological properties and quality characteristics of dried ogi supplemented with date flour as sugar substitute. Dried ogi supplemented at varying proportions with date flour (90:10, 80:20, 70:30, 60:40 and 50:50) was evaluated for chemical composition, functional, pasting properties and rheological properties. The sensory evaluation of pap from ogi-date flour blends and colour attributes were also evaluated. The viscosities were determined at room temperature using a digital rotation NDJ-86 Viscometer. Shear stress (σ) *and* consistency index 'k' of respective pap made from Ogi-date powder blends at varying spindle speed (12, 30 and 60 RPM) and time (5, 10, 15, 20, 25 sec), respectively decreased with increase in spindle speed. The flow behaviour index 'n' ranged between 0.999 and 1.0078. There was a significant difference ($p<0.05$) between values obtained for moisture contents and these ranged from 6.64-7.28%. The fat and ash contents increased up to 20 and 30%, respectively with increase in proportion of dates flour added. The bulk density and water absorption capacity (WAC) increased with increase in proportion of dates flour added. From the results, it can be deduced that sample HAP6(*60% Ogi flour + 40% Date flour)* has the highest value of Total titrable Acidity(TTA) In conclusion, the results of sensory evaluation showed that sample LKJ9 (90% Ogi flour + 10% Date flour) was the most preferred among all the samples.

Key words: Rheological properties; quality; dried ogi; date flour; sugar substitute.

1. Introduction

Ogi is a popular fermented food produced from common cereals. It is often consumed as weaning food by infants, common food for convalescents and breakfast cooked gruel by adults (Bolaji *et al.,* 2017a; Bolaji *et al.,* 2014; Jude-Ojei *et al.,* 2017). Textural quality and colour of Ogi porridge depends on type of cereal grains, variety and supplement added to it (Bolaji *et. al.,* 2017a; Bolaji *et al.,* 2017). Considerable nutrient losses mostly located in the testa and germ have been widely reported during the processing of maize into ogi (Aminigo & Akingbala, 2004; Bolaji *et al.,* 2018).

Some level of fortifications of ogi slurry with varieties of legumes has been reported by several researchers (Aminigo & Akingbala, 2004; Otunola *et. al.,* 2007; Bolaji *et al.,* 2018). The focuses of many of these studies were on nutrition and shelf life.

The consumption of ogi-pap is often with varieties of supplements. Mostly sugar, milk and beverages are used by convalescents, young and children.

In most cases, processed sugar is often added to the Ogi to sweeten it by majority of consumer. This may have detrimental health effects on consumers as this may increase sugar intake and also increase the risk of obesity, diabetes and cancer (Prada *et al.,* 2020; Gulati & Misra, 2014). Therefore, the use of natural sweeteners such as date flour may help in reducing the intake of processed sugar and improve the health of consumers. Although, it is a natural sweetener, according to some researchers, date palm seeds contain about 0.56–5.4% lauric acid and oleic acid (Manickavasagan *et al.,* 2015). Studies have revealed that feeding mice with the aqueous extract of date pits exhibit anti-genotoxic effects and reduced DNA damage induced by N-nitroso-N-methylurea (Diab & Aboul-Ela, 2012). It is also a good source of bioactive compounds (Manickavasagan *et al.*, 2015; Sirisena *et al.*, 2015). Previous studies showed that date fruit is a good source of high energy, calcium, chlorine, copper, magnesium and sulfur, and a minor source of 16 amino acids and vitamins A_1, B_1 and B_2 (Tang *et al.,* 2013; Sultana *et al.,* 2015). Date fruits have been included in juice, syrups, and spreads and many value added products for industrial ethanol, bakery yeast, folder yeast and citric acid (Tang *et al.,* 2013; Manickavasagan *et al.,* 2013; Bolaji *et al.* 2022). Apart from sweetening the ogi, date flour are reported to have dietary fibre, phenolic compounds, minerals, vitamins and antioxidant compounds (Siddiqi *et al.*, 2020).

However, irrespective of fortification and substitution of supplement in food, the rheological properties, nutritional, functional, pasting properties and colour are subjected to being affected because of the substitutions (Osungbaro, 1990). Food rheology studies consistency and flow of food under highly specified conditions (McKenna & Lyng, 2003). The consistency, degree of fluidity, and other mechanical properties are important in understanding how long food can be stored and in determining food texture; acceptability and quality control during food manufacturing process (Herh *et al.*, 2000).

Therefore, the objectives of this study were to evaluate rheological properties and quality of dried ogi supplemented with date flour as sugar substitute.

2. Materials and Methods

2.1. Materials

Dried maize grain and date fruits used for this study were purchased in Odogunyan market, Ikorodu, Lagos, Nigeria.

2.2. Methods

2.2.1. Preparation of Ogi flour

Maize grains were thoroughly cleaned and foreign materials carefully removed. The grains were soaked in water for 72 h at room temperature (27±3) This was subsequently decanted, wet milled with attrition mill and sieved with muslin cloth (0.2 um). The residue was discarded while the filtrate was fermented for 24h. The Ogi was put in a sack and pressed with a screw press and more water was removed. The Ogi granules were fed into the locally fabricated flash drier and converted to fine dry Ogi flour. Ogi flour was packaged in Ziploc bag until used for analysis.

2.2.2. Preparation of date flour

The dates were cleaned to remove foreign bodies. The dates were pitted to remove the core nut. The pitted dates were washed in a running water to remove any sticking foreign bodies and dried in cabinet drier at 60 °C for 12 h.

The dried dates were fed into the hammer mill and milled to fine flour. Date flour was packaged in Ziploc bag until used for analysis.

2.2.3. Preparation of ogi-date flour blends

Ogi and date flours were blended. An electronic digital weighing scale was used to measure the ogi and date flours in the ratios of 90:10, 80:20, 70:30, 60: 40 and 50:50, respectively. The blended Ogi-date flour was thoroughly mixed in a sealed container for about 90s and was ready for analysis which was conducted following standard procedures.

2.2.4. Viscosity determination

The procedure described by Bolaji *et al.* (2017b), was used to determine the viscosity of the samples. About 100 g of the ogi produced from maize with date was placed inside a measuring cylinder and 400 mL of hot water was added and stirred consistently till the ogi solution gelatinized. The viscosities of gelatinized samples were then measured with aid of viscometer. The pap was poured into the beaker, above the immersion groove on the spindle shaft. All the measurements were taken immediately after the gelatinized ogi was produced. The viscosities of ogi samples were carried out at room temperature (27±3) using NDJ-897 Viscometer. The analysis was done using spindle rotating at different speed revolution of 12, 30 and 60 rpm. The viscosities data obtained were used to compute the shear stress and shear rate respectively. A plot shear stress against shear rate at different speed of revolution 12, 30 and 60 rpm was done and power law was used to test the appropriateness of the model. Viscosity of a solution as a function of shear rate is given via the power law equation, where 'n' is the viscosity, 'k' is a material based constant and 'γ' is the applied shear rate (Bolaji *et al.*, 2017b).

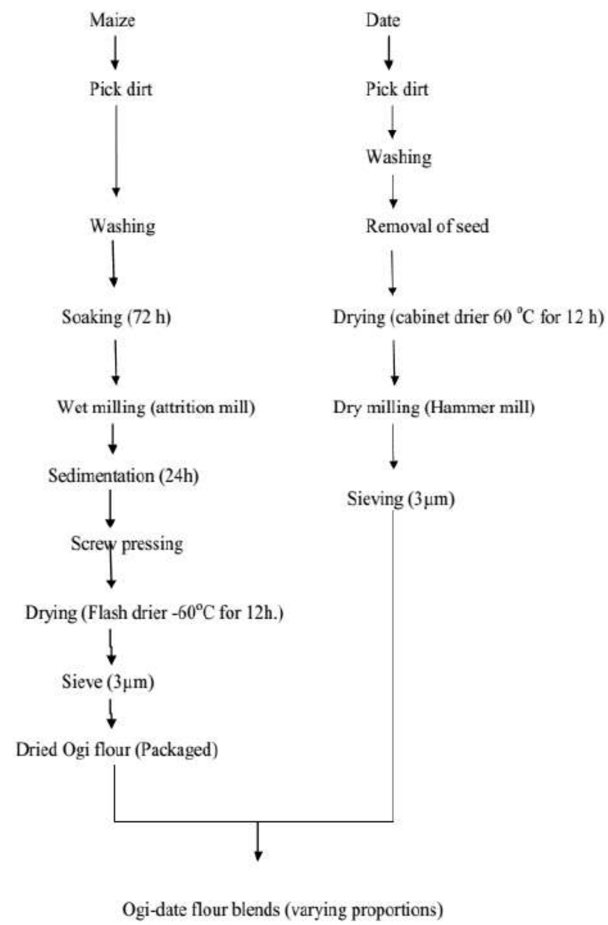

Figure 1: Flow diagram for the preparation of Ogi-date flour blends

2.2.5. Determination of pasting properties

Determination of pasting properties of flour blends was done using by the Rapid Visco Analyser (RVA TECMASTER, Perten Instrument) method as described by Scientific (1998).

The pasting property of the Ogi-date blend samples were mixed with 25 mL distilled water and placed into the canister. The designated paddle was fixed into the canister and placed inside the Rapid visco Analyser (RVA). The RVA machine was set at 40°C and allowed to run for 20 min. The canister was removed on the completion of test while the result was tabulated with corresponding graphical representation. The peak, trough, breakdown, final and setback viscosities for each sample were measured alongside the Pasting temperature and pasting time.

2.2.6. Determination of proximate composition

The moisture, protein, fat, crude fibre and ash contents were determined by using standard methods described by AOAC (2005). The carbohydrate contents of the samples determined by difference using the formula as shown in equation 1:

% carbohydrate = 100 - (% moisture + % ash + % crude fibre + % crude protein + % fat) (1)

2.2.7. Determination of chemical composition

The total titrable acidity (lactic acid base) was determined by titrating 0.1M NaOH against 20 mL prepared from 8 g of Ogi diluted with 80 mL of distilled water (AOAC, 1984). The percent TTA was computed as shown in equation 2.

$$\%\ titratable\ acidity = \frac{ml \times N \times 90 \times 100}{V \times 1000} \qquad (2)$$

Where:

-mL is ml 0.1 NaOH used

-N is normality of 0.1 N NaOH

-V is mLOgi solution used

The pH was determined using a hand held pH meter. The pH was then calibrated using standard buffer solution at pH 4.0 -7.0. The pH was determined by dipping the hand held pH meter in the sample solution. This was replicated thrice.

2.2.8. Determination of functional properties

The bulk density (g/cm^3) was determined using the method reported by Okaka *et al.* (2006).

Five grams (5 g) was weighed into a 50mL graduated measuring cylinder. The samples were packed by gently tapping the cylinder on the bench top for about ten (10) times from height of 5cm. The volume of the samples was recorded was used to compute the bulk density of the ogi-date blend sample.

Bulk density (g/cm^3) = weight of the sample/ Final volume of the tapped blend. The Water/oil absorption capacity were determined by method of AOAC (2005).

Water absorption index was determined using the modified method (Bolaji *et al.,* 2017a). The 2.5g of the sample was suspended in 30ml distilled water at 30°C in a centrifuge tube, stirred for 30 min. intermittently and centrifuged. The weight of the gel formed was recorded and the water absorption index (WAI) was calculated as gel weight per gram dry sample.

Swelling index determination was determined by the method described by Elaveniya & Jayamuthunagai (2014). One gram (1g) of the ogi-date blends was weighed into 5mL centrifuge tube and 50mL of distilled water was added and mixed gently. The slurys were heated in a water bath at temperature 80°C and 100°C, respectively for 15 min. During heating, the mixtures were stirred gently to prevent clumping of the mixture. The tubes with the mixture were subsequently transferred and centrifuged at 3000 rpm for 10 min. The supernatant were decanted immediately after centrifugation. The weight of the sediments were taken and recorded while the moisture content of the sediment gel was used to determine the dry matter content of the mixture as shown in equation 3.

$$\text{Swelling power} = \frac{\text{weight of wet mass sediment}}{\text{Weight of dry matter in gel}} \quad (3)$$

2.2.9. Determination of colour attribute of samples

The colour intensity of the ogi-date samples was assessed using a Konica Minolta Colour Measuring System (Chroma Meter CR-410, Minolta LTD Japan). The lightness (L*), redness or greenness (a* or –a*), and yellowness values were obtained after calibrating the instrument using a white tile. Three replicate readings were taken for each samples and the average value were reported. The results were expressed in accordance with the CIE lab system.

2.2.10. Sensory evaluation of the samples

The method reported by Bolaji *et al.* (2011) was employed. About 100 g of ogi slurry was measured from each sample and about 50 mL of cold water was added and stirred in a bowl and gelatinized with boiled water (100°C), in this case. The same amount of water (400 mL) was used for all the samples. It was stirred until porridge (ogi) was obtained and sensory evaluation was carried-out. The sensory attributes of the "ogi" samples were evaluated using hedonic scale. This was done using 20 panelists familiar with the ogi. Each panelist was asked to score each attribute on a nine-point hedonic scale where one and nine represent liked extremely and disliked extremely, respectively. The attributes evaluated were colour, aroma, taste, consistency and overall acceptability. Data obtained were subjected to statistical analysis using ANOVA to detect the differences in the mean scores. 20-member panelists comprising of people who are conversant with the products and they were engaged for the sensory evaluation exercise.

2.2.11. Statistical analysis

All collected data were subjected to analysis of variance (ANOVA) using SPSS (Version 15, 2001). Duncan multiple test was used to separate the difference in the mean score ($p<0.05$).

3. Results and discussion

3.1. Rheological properties

The results of the rheological properties of the samples are as shown in Table 1. The viscosities of respective pap made from Ogi -date flour blends were determined at varying spindle speed (12, 30 and 60 RPM) and time (5, 10, 15, 20, 25 sec), respectively. The results revealed that the viscosities were affected by the spindle speed. The viscosities decreased with increase in spindle speed. The shear stress (*σ)* and consistency index 'k' also decreased with increase in the spindle speed. This may be due the increasing alignment of constituent molecules during shearing at increased speed (Bodbodak *et al.,* 2013). The viscosities data were fitted with power law model (Eq. 1) to determine the rheological parameters (consistency (k), flow behaviour index (n) and the coefficient of determination (R^2), respectively (Seyssiecq *et al.,* 2003; Gao & Kisper, 2003).

$$\sigma = k\gamma^n \quad (1)$$

The flow behaviour index 'n' ranged between 0.999 and 1.0078. A similar observation was reported by some researchers for, juice of "Totapuri and mango Jam (Dak *et al.,* 2006; Santanu and Shivhare, 2010).

The values flow behavior index (n) obtained in this research work were in the range of values reported for Juice "MalasYazdi" Pomegranate by some researchers (Bodbodak *et al.,* 2013). However, the results were higher when compared with values reported for ketchup, tomato paste and tomato ketchup (Koocheki *et al.,* 2009; Bayod *et al.,* 2008; Gujral *et al.,* 2002) According to Rao (1999), the non-Newtonian behavior of any food material is widely determined by dissolved polymers or dispersed nature of food. The dispersed phase may be the insoluble solids or the immiscible fluids. Mohamed *et al.* (2019) reported that the addition of date fruit syrup in corn gel indicated a significant increase in the pasting properties of corn starch and supported the application of syrup from date fruit in the food industries. The rheological properties of ogi –date pap certainly will help in the effective handling and processability, shelf stability of the ogi-date pap, and digestibility (Zheng, 2019).

3.2. Pasting properties of powdered ogi blended with powdered dates

The results for pasting properties are as shown in Table 2. The pasting property is one of the most important properties that influence quality and aesthetic consideration in the food industry since they affect texture and digestibility as well as the end use of starch based food commodities (Onweluzo & Nnamuchi, 2009). Peak viscosity ranged from 1033.00-3416.00cp. There were significant ($p<0.05$) differences in peak, trough, break down, final and set back viscosities between all the samples and decreased with increase in the inclusion of date flour. Values obtained in this work for peak, trough, break down viscosities followed similar trend as reported by Jude-ojei *et al.* (2017) for ogi-moringa blends, Otunola *et al.* (2007) for Ogi with okra seed flour blend; Fasoyiro & Arowora (2013) for ogi-pigeon pea flour blends and Olorode *et al.* (2013) for Ogi with moringa leaves. High peak viscosity is an indication of high starch content related to the water binding capacity of starch (Adebowale *et al.,* 2005). Dates flour addition is an indication that the flour can be used to produce products that require low gel strength and elasticity (Adebowale *et al.,* 2005). The trough viscosity is the minimum viscosity value in the constant temperature phase of the RVA pasting profile and it measures the ability of the paste to withstand breakdown during cooling (Arisa *et al.,* 2013). Break down viscosity measures the ability of paste to withstand breakdown during cooling. The higher the value of break down viscosity, the greater the ability of starch to withstand breakdown (Adegunwa *et al.,* 2017; Adebowale *et al.,* 2005). The decrease in the break down and final viscosity values could be attributed to the relative increase in fibre content which had the ability to decrease the stability of the food system during processing and storage. High values indicate little breakdown of sample starches (Opeifa *et al.*, 2015; Adegunwa *et al.,* 2017). The final viscosity is a measure of stability of the granules; it indicates the ability of the powder to form a gel or viscous paste after cooking and cooling (Adebowale *et al.,* 2005). High setback is also associated with syneresis (Niba *et al.,* 2001), therefore setback viscosity in 100% ogi powder is an indication of greater tendencies towards retrogradation compared to samples from blends of date flour and ogi flour with low setback viscosities. This would play a major role in the sensory texture acceptance of the resulting product when prepared.

Table 1: Rheological parameters

		k		R^2
TAD1	12	10424	0.9999	0.99963
	30	4172.1	1.0000	0.9999
	60	2086.4	1.0000	0.999999
LKJ9	12	51763	0.9984	0.999999
	30	20836	0.9997	0.999999
	60	10435	0.9998	0.99999
DUP8	12	52123	1.00	0.9999
	30	20852	1.000	0.999999
	60	10423	0.99995	0.99999
SLB7	12	52117	1.00	0.99999
	30	20846	1.0000	0.999999
	60	10434	0.99999	0.999999
HAP6	12	50648	1.0078	0.9998
	30	20857	1.000	0.999999
	60	10431	0.999999	0.99999
TLM5	12	52112	1.000	0.99999
	30	20857	1.000	0.99999
	60	10439	1.000	0.99999

KEY
***TAD1** 100% Ogi flour, **LKJ9** 90% Ogi flour + 10% Date flour, **DUP8** =80% Ogi flour + 20% Date flour, **SLB7** 70% Ogi flour + 30% Date flour, **HAP6** 60% Ogi flour + 40% Date flour, **TLM5** 50% Ogi flour + 50% Date flour*

Peak time is a measure of the cooking time (Adebowale *et al.,* 2005). Peak time of the ogi flour blended with date flour ranged between 4.87 – 5.23 min with powder blend from 50% ogi flour and 50% date flour having the highest value of 5.23 min. This suggests more processing time. There was a significant difference ($p<0.05$) in the peaks. Values obtained in this work were higher than values reported by Fasoyiro and Arowora (2013) for Whole Fermented Maize (Ogi). The pasting temperature provides an indication of minimum temperature required for cooking the samples. The pasting temperature ranged between 75.08 and 89.23°C with sample TLM5 recorded higher values. This was contrary to values reported for Ogi Produced from Fermented Maize and Horse Eye Bean by Opeifa *et al.* (2015).

3.3. The proximate composition of ogi and date flour blends

The results of proximate composition of powdered ogi blended with date flour are presented in Table 3. The moisture contents of the samples ranged from 6.64-7.28% and were within the range reported for date palm fruit by Ogungbenle (2011). There was significant difference ($p<0.05$) between all the samples. There was increase in moisture content with up to 30% and 50% date flour addition. This suggested that the dried date fruits and dried ogi were not within the same moisture regime before mixture. The protein contents of the samples ranged from

Table 2: Pasting properties of ogi and date flour blends

Samples	Peak Viscosity (cP)	Trough Viscosity (cP)	Breakdown Viscosity (cP)	Final Viscosity (cP)	Set Back (cP)	Peak Time (Mins)	Pasting Temp. (^{0}C)
TAD1	3416.00±48.08^{a}	2010.50±50.20^{a}	1405.50±2.12^{a}	2878.00±52.33^{a}	867.50±2.12^{a}	4.90±0.05^{c}	75.08±0.11^{e}
LKJ9	2815.00±80.61^{b}	1744.50±50.20^{b}	1070.50±30.41^{b}	2500.00±76.37^{b}	755.50±26.16^{b}	4.87±0.00^{c}	75.85±0.07^{e}
DUP8	2059.00±7.07^{c}	1441.00±8.49^{c}	618.00±15.56^{c}	1980.50±23.33^{c}	539.50±31.82^{c}	5.03±0.05^{b}	77.88±0.60^{d}
SLB7	1711.00±2.83^{d}	1324.50±2.12^{d}	386.50±0.71^{d}	1725.00±7.07^{d}	400.50±9.19^{d}	5.13±0.00^{ab}	79.88±0.11^{c}
HAP6	1317.00±2.83^{e}	1105.00±9.90^{e}	212.00±7.07^{e}	1330.50±9.19^{e}	225.50±19.09^{e}	5.20±0.09^{a}	86.38±0.04^{b}
TLM5	1033.00±0.00^{f}	922.50±0.71^{f}	110.50±0.71^{f}	1048.50±0.71^{f}	126.00±1.41^{f}	5.23±0.05^{a}	89.23±0.67^{a}

**Mean ± standard deviation with same superscripts along the column are not significantly different at (p>0.05)*
KEY
***TAD1** 100% Ogi flour, **LKJ9** 90% Ogi flour + 10% Date flour, **DUP8** =80% Ogi flour + 20% Date flour, **SLB7** 70% Ogi flour + 30% Date flour, **HAP6** 60% Ogi flour + 40% Date flour, **TLM5** 50% Ogi flour + 50% Date flour*

Table 3: The proximate composition of ogi and date flour blends

Sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fibre (%)	CHO (%)
TAD1	6.64±0.01^{e}	10.07±0.01^{c}	2.14±0.01^{g}	0.87±0.02^{d}	1.87±0.01^{c}	78.45±0.01^{a}
LKJ9	6.74±0.01^{d}	10.22±0.01^{b}	3.98±0.01^{f}	0.42±0.01^{g}	1.52±0.01^{e}	77.09±0.01^{b}
DUP8	6.96±0.01^{b}	13.41±0.01^{a}	8.96±0.01^{a}	0.92±0.01^{c}	1.88±0.01^{c}	67.88±0.01^{g}
SLB7	7.28±0.02^{a}	6.78±0.01^{g}	6.72±0.01^{c}	1.76±0.02^{a}	2.53±0.01^{a}	74.88±0.01^{f}
HAP6	7.27±0.02^{a}	7.13±0.01^{f}	7.32±0.01^{b}	0.65±0.01^{f}	1.77±0.01^{d}	75.87±0.01^{c}
TLM5	6.88±0.01^{c}	9.04±0.01^{e}	6.43±0.01^{d}	0.84±0.01^{e}	1.88±0.01^{c}	74.94±0.01^{e}

**Mean ± standard deviation with same superscripts along the column are not significantly different at (p>0.05)*
KEY
***TAD1** 100% Ogi flour, **LKJ9** 90% Ogi flour + 10% Date flour, **DUP8** =80% Ogi flour + 20% Date flour, **SLB7** 70% Ogi flour + 30% Date flour, **HAP6** 60% Ogi flour + 40% Date flour, **TLM5** 50% Ogi flour + 50% Date flour*

6.78 to 13.41%. The highest was found in 80% Ogi powder blended with 20% date flour while the lowest was observed in 70% ogi flour blended with 30% date flour. There was significant difference ($p<0.05$) among all the samples. The protein content was observed to increase up to 20% in proportion of date flour. The Inclusion of date flour suggested possible addition of some amino acids (Sultana *et al.,* 2015). The fat content of the powdered ogi blended with date flour ranged from 2.14-8.96%. There was a significant ($p<0.05$) difference among all the samples. The fat content was observed to increase with up to 20% increase in proportion of date flour. The increased fat content after drying is mainly due to moisture loss.

Table 4: Functional properties of ogi with date flour blends

Sample	Bulk Density (g/ml)	Water Absorption Capacity (%)	Oil Absorption Capacity (%)	Swelling Capacity (%)	Solubility (%)
TAD1	0.69 ± 0.02^{c}	71.67 ± 0.58^{a}	80.67 ± 0.58^{a}	7.09 ± 0.08^{b}	2.33 ± 0.58^{d}
LKJ9	0.72 ± 0.02^{c}	76.00 ± 6.93^{a}	62.67 ± 9.29^{b}	7.61 ± 0.02^{a}	1.77 ± 0.40^{d}
DUP8	0.71 ± 0.00^{bc}	69.00 ± 1.73^{a}	77.33 ± 0.58^{a}	7.10 ± 0.09^{b}	5.67 ± 0.58^{c}
SLB7	0.79 ± 0.02^{b}	69.67 ± 5.13^{a}	75.00 ± 1.73^{a}	6.53 ± 0.13^{c}	10.33 ± 0.58^{b}
HAP6	0.77 ± 0.00^{b}	66.00 ± 8.72^{a}	61.00 ± 3.61^{b}	7.89 ± 0.51^{a}	4.67 ± 1.15^{c}
TLM5	0.83 ± 0.00^{a}	71.33 ± 9.29^{a}	77.00 ± 2.65^{a}	7.71 ± 0.11^{a}	12.33 ± 0.58^{a}

**Mean ± standard deviation with same superscripts along the column are not significantly different at (p>0.05)*
KEY
TAD1 *100% Ogi flour;* ***LKJ9*** *90% Ogi flour + 10% Date flour;* ***DUP8*** *=80% Ogi flour + 20% Date flour;* ***SLB7*** *70% Ogi flour + 30% Date flour,* ***HAP6*** *60% Ogi flour + 40% Date flour,* ***TLM5*** *50% Ogi flour + 50% Date flour*

However, these differences may be expected due to differences in cultivation, drying conditions, and determination methods. The importance of lipids in food substances cannot be overemphasized as it contributes significantly to the energy value of foods. Ash content of the ogi flour blended with date flour ranged from 0.42-1.76%. The highest was found in 70% ogi flour blended with 30% date flour while the lowest was observed in 90% ogi flour blended with 10% date flour. There was a significant difference ($p<0.05$) among all the samples. The ash content increased with an increase in proportion of date flour up to 30% indicating that date flour contributed appreciably to the mineral content ogi-date flour.

The high ash content present in date fruit was reported by Sultana *et al.* (2015) for date fruits available in the Bangladeshi local markets. Higher ash content in date indicated that the total inorganic mineral is high (Oloyede, 2005).

The crude fibre content of the powdered ogi with date flour blends ranged from 1.52-2.53%. The highest was found in 70% ogi with date flour blends with 30%. There was significant difference ($p<0.05$) among all the samples but for sample TDA1, DUP8 and TLM5. Values obtained in this research work for crude fibre were lower compared to values reported by Sultana *et al.* (2015). The presence of high fibre in food products have been linked with the ability to facilitate bowel movement (peristalsis), bulk addition to food; it decreases serum cholesterol levels and prevents many gastro intestinal diseases in man (Satinder *et al.,* 2011; Ekpo, 2007). The carbohydrates contents of ogi with date flour blends ranged from 67.88-78.45%. The highest was recorded for 100% ogi flour. There was a significant difference ($p<0.05$) among all samples.

3.4. Functional properties of ogi with date flour blends

The functional properties of the food materials are very important for the appropriateness of the diet, behaviour of nutrients in food during processing, storage and preparation because they affect the general quality of foods as well as their acceptability (Omueti *et al.,* 2009). The results of functional properties of the ogi-date flour blends are presented in Table 4. There was significant differences ($p<0.05$) among the samples. The bulk density increased with increase in proportion of powdered date. This indicated that the date flour may have influenced this increase the particle size and have possible implication for packaging and transportation of these products

(Fagbemi, 1999). The water absorption capacity (WAC) increased with an increase in proportion of date flour for up to 10%. The increase in WAC implies high digestibility of the starch. Its characteristics represent the ability of the product to associate with water under condition where it is limiting in order to improve handling (Giami, 1993). Water binding capacity is a useful indication of whether powder or isolates can be incorporated into aqueous food formulations (Giami, 1993).

The oil absorption capacity of the ogi blended with date ranged from 61.00-80.67%. The highest was found in 100% ogi flour. There was a significant ($p<0.05$) difference between samples. Blending of ogi with date flour decreased the oil absorption capacity. The swelling capacity of the ogi with date flour blends ranged from 6.53-7.89%. A higher value was found in 60% ogi flour blended with 40% date flour. There was a significant ($p<0.05$) difference between the samples. There was an increase in the swelling capacity of the blended ogi samples in comparison to the value obtained for 100% ogi flour although they compared lesser with the value reported by Ijarotimi *et al.* (2009) for ogi from 100% maize (13.7%). The solubility of the ogi with date flour blends ranged from 1.77-12.33%. There was an increase in solubility from 20-50% date flour addition though not progressively.

3.5. Mineral composition of powdered ogi blended with powdered dates

The results of mineral composition of the ogi with date flour blends are presented in Table 5. It has been established that minerals are important as constituents of many part of the human bodies (Ekpo, 2007). Potassium is vital to cellular integrity and fluid balance as it plays an important

Table 5: Mineral composition of ogi with date flour blends

Sample	Potasium (mg/100g)	Sodium (mg/100g)	Iron (mg/100g)	Calcium (mg/100g)	Zinc (mg/100g)
TAD1	110.75±0.002^{e}	11.85±0.001^{a}	1.64±0.001^{f}	7.80±0.001^{c}	0.19±0.001^{f}
LKJ9	85.75±0.001^{f}	10.41±0.001^{e}	1.68±0.001^{e}	7.13±0.001^{d}	1.20±0.001^{a}
DUP8	93.25±0.001^{d}	10.41±0.001^{f}	2.83±0.001^{b}	8.59±0.001^{b}	0.33±0.001^{c}
SLB7	91.25±0.001^{e}	11.23±0.001^{c}	7.63±0.001^{a}	9.33±0.001^{a}	0.90±0.001^{b}
HAP6	126.00±0.001^{a}	10.72±0.001^{d}	2.47±0.001^{d}	6.99±0.001^{e}	0.29±0.001^{e}
TLM5	121.25±0.001^{b}	11.40±0.001^{b}	2.49±0.001^{c}	6.84±0.001^{f}	0.29±0.001^{d}

**Mean ± standard deviation with same superscripts along the column are not significantly different at (p>0.05)*
KEY
***TAD1** 100% Ogi flour, **LKJ9** 90% Ogi flour + 10% Date flour, **DUP8** =80% Ogi flour + 20% Date flour, **SLB7** 70% Ogi flour + 30% Date flour, **HAP6** 60% Ogi flour + 40% Date flour, **TLM5** 50% Ogi flour + 50% Date flour*

role in nerve function. It also helps to metabolize proteins and carbohydrates in energy production, and regulates heart beat (Ekpo, 2007). The amount of potassium present in the ogi with date flour blends ranged from 85.75-126.00 mg/100g. The highest was found in 60% ogi flour blended with 40% date flour There was a significant ($p<0.05$) difference between all the samples. There was an increase in the potassium content of the blended ogi samples from 50-60% date flour addition though not progressively. These were unconnected with the availability in date (Uba *et* *al.,* 2015; Sultana *et al.,* 2015). The amount of sodium present in the ogi with date flour blends ranged from 10.41-11.85 mg/100g. There was a decrease in the sodium content of the blended ogi samples with date flour addition though not progressively.

The amount of iron present in the ogi with date flour blends ranged from 1.64-7.63 mg/100g. There was significant difference ($p<0.05$) between all the samples. There was an increase in the iron content of the ogi with date flour blends though not progressively. The amounts of calcium present in the ogi with date flour blends ranged from 6.84-9.33 mg/100g. There was a significant difference ($p<0.05$) between all the samples. There was an increase in the calcium content of the blended ogi samples with up to 30% dates powder addition. Calcium helps to keep muscles working correctly and it works with phosphorus to help with bone strength and growth (El-Sohaimy and Hafez, 2010). The amount of zinc present in the ogi with date flour blends ranged from 0.19-1.20 mg/100g. There was a significant difference ($p<0.05$) between all the samples. There was an increase in the zinc content of the ogi with date flour blends though not progressively. Zinc has been considered to have anti-cancer properties (Saada *et al.,* 2012).

3.6. Colour properties, pH and TTA

Colour is an important attribute in product because it can arouse individual's appetite (Pereira *et al.,* 2013). The L*, a* and b* values of the ogi samples are presented in Table 6. The positive values of b* indicated the predominance of yellowness while the negative values of a* indicated the predominance of greenness in the ogi samples. The colour of ogi samples changed to brown from cream colour as the inclusion of date flour increased. Colour parameters of tested

Table 6: The colour, TTA and pH of ogi blended with date fruits

Sample	L*	-a*	b*	TTA	pH
TAD1	$72.03±0.01^{bc}$	$-12.88±0.01^{g}$	$25.30±0.01^{b}$	0.131	3.46
LKJ9	$72.74±0.01^{bc}$	$-12.26±0.01^{f}$	$24.62±0.01^{b}$	0.187	4.28
DUP8	$70.18±2.44^{c}$	$-8.26±0.28^{e}$	$23.71±0.93^{c}$	0.159	4.02
SLB7	$64.79±1.52^{d}$	$-4.71±0.09^{b}$	$22.25±0.53^{d}$	0.168	4.00
HAP6	$65.03±2.97^{d}$	$-6.65±0.29^{c}$	$21.66±1.07^{d}$	0.196	4.35
TLM5	$54.24±0.01^{f}$	$-4.79±0.02^{b}$	$17.88±0.02^{f}$	0.177	4.30

**Mean ± standard deviation with same superscripts along the column are not significantly different at (p>0.05)*
KEY
***TAD1** 100% Ogi flour, **LKJ9** 90% Ogi flour + 10% Date flour, **DUP8** =80% Ogi flour + 20% Date flour, **SLB7** 70% Ogi flour + 30% Date flour; **HAP6** 60% Ogi flour + 40% Date flour, **TLM5** 50% Ogi flour + 50% Date flour*

ogi-date fruits blends samples showed that sample TLM5 was darker compared with other samples, obviously because of its higher inclusion of dates, where it had the lowest lightness (l* = 54.24). The value for greenness (a*) of the ogi-date flour samples ranged from -4.71 – -12.88. The values for yellowness (b*) was at maximum in sample TAD1 (25.30) compared with sample TLM5 (17.88).

The TTA values ranged from 0.168-0.196 while the values for pH ranged from 3.46-4.35. The values obtained in this work were lesser than the values obtained by Nwokoro & Chukwu (2012) for akamu (0.48) and may have been affected by length of sedimentation. The significance of TTA in a food product is connected with its ability to influence the flavor of such product (Sadler & Murphy, 2010). The significance of pH of a food product is that it could determine the ability of microbial grow in such products (Sadler & Murphy, 2010).

3.7. Sensory evaluation of pap produced from ogi with date flour blends

The sensory scores associated with the ogi with date flour blends are shown in Table 7. There was a significant difference ($p \leq 0.05$) in the values obtained from score of taste, colour, flavor and texture The scores for colour, texture, flavor and taste of the ogi with date flour blends ranged from 4.50–7.35, 5.10-7.25, 4.65–7.40 and 5.00-7.15, respectively. However, 100% ogi flour was scored higher in colour, flavor, and texture. A decreasing trend in texture was observed with increase in date flour addition. There was a significant ($p<0.05$ difference) between the texture of the ogi produced from 20-40% date flour addition and the other samples. The scores for appearance of the ogi with date flour blends ranged from 5.45 – 7.35. The highest appearance rating was found in 100% ogi flour while the lowest was observed in 50% ogi flour blended with 50% date flour. A decreasing trend in appearance was observed with increase in date flour addition.

It was evidently clear that overall acceptability of the ogi with date flour blends was influenced by the organoleptic attributes of colour, texture, flavor, taste and appearance. There was a significant difference ($p<0.05$) in the degree of acceptance among the samples. The 100% ogi flour was liked very much (8.05) but 90% ogi flour blended with 10% date flour faired moderately in comparison to the former, although it was liked moderately (7.30). Sensory scores by panelist may not be unconnected with the fact that about 50% of the respondents confirmed not to have taken any product from date fruit before, although date fruit is known for its sweet and savory taste and is even utilized as replacement for sugar. But cultural peculiarity of the panelists may be one of the reasons for the relatively low ratings observed for ogi with date flour blends along increasing dark brown colour exhibited by increased inclusion of date fruit flour.

Table 7: The sensory evaluation of ogi with date flour blends

Samples	Colour	Texture	Flavour	Taste	Appearance	Overall Acceptability
TAD1	7.80 ± 1.239^{a}	7.25 ± 1.37^{a}	7.40 ± 0.82^{a}	7.75 ± 0.64^{a}	7.35 ± 1.18^{a}	8.05 ± 0.76^{a}
LKJ9	6.95 ± 0.83^{a}	6.50 ± 1.24^{ab}	6.45 ± 1.10^{b}	7.15 ± 0.59^{b}	6.70 ± 1.08^{ab}	7.30 ± 0.57^{b}
DUP8	5.90 ± 0.85^{b}	5.90 ± 0.85^{bc}	5.55 ± 0.83^{c}	6.55 ± 0.69^{c}	5.95 ± 1.15^{bc}	6.30 ± 0.57^{c}
SLB7	5.60 ± 0.88^{bc}	5.90 ± 5.90^{bc}	5.70 ± 0.80^{c}	5.95 ± 0.89^{d}	5.75 ± 1.25^{c}	5.75 ± 0.91^{cd}
HAP6	5.20 ± 1.11^{c}	5.85 ± 1.18^{bc}	5.50 ± 1.28^{c}	5.75 ± 0.91^{e}	6.10 ± 1.45^{bc}	5.45 ± 0.94^{d}
TLM5	4.50 ± 1.24^{d}	5.10 ± 1.07^{c}	4.65 ± 1.35^{d}	5.00 ± 1.17^{f}	5.45 ± 1.85^{c}	4.75 ± 1.45^{e}

**Mean ± standard deviation with same superscripts along the column are not significantly different at (p>0.05)*

KEY

TAD1 *100% Ogi flour,* ***LKJ9*** *90% Ogi flour + 10% Date flour,* ***DUP8*** *=80% Ogi flour + 20% Date flour,* ***SLB7*** *70% Ogi flour + 30% Date flour,* ***HAP6*** *60% Ogi flour + 40% Date flour,* ***TLM5*** *50% Ogi flour + 50% Date flour*

4. Conclusion

The shear stress-shear rate data of ogi pap indicated that ogi could be described as Newtonian and non-Newtonian depending on the prevalent conditions and probably starch composition as described by power law. It has also been shown that the higher the spindle speed(rpm), the lower the viscosity of samples and vice versa. The viscosities, shear stress (*σ)* and consistency index 'k' of respective pap made from ogi -date flour blends at varying spindle speed (12, 30 and 60 RPM) and time (5, 10, 15, 20, 25 sec), respectively decreased with increase in spindle speed. This suggests the criteria to consider in the design of processing unit like mixing and transportation for this food and also the possible characteristics processing and packaging. It may be necessary during possible online processing for pipes to be employed to convey it over short or long distances, the rheological characteristic becomes necessary. However, in terms of overall acceptability the control (100% ogi flour) was the most acceptable to the panelists, because of the appearance in comparison with what the consumer were used to. Apart from adding value and varieties to ogi due to its mineral improvement, fortifying ogi with date flour at 30% substitution level would also reduce the problem of food security especially among children in the sub-Sahara region of Africa where malnutrition due to deficiency of essential micro nutrients is common. Also, the shelf stability of these blends in the dry form is sustainable and should be considered for commercialization.

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None

Conflict of interest

The authors declare that they have no competing interests.

Ethics

This Study does not involve Human or Animal Testing.

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