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Total phenol, proximate composition, pasting and functional properties of composite Wheat Tiger nut flour

V CWabali[1*], B O Ukemenam[2], I N Okwunodulu[3]
[1] Department of Food, Nutrition and Home Science, Faculty of Agriculture, University of Port -Harcourt, Port Harcourt, Nigeria
[2] Department of Crop and Soil Science, Faculty of Agriculture, University of Port-Harcourt, Port-Harcourt, Nigeria
[3] Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria

Abstract
Composite flour of wheat and Tigernut (A= WHF 100: TNF 0; B= WHF 75: TNF 25; C= WHF 50: TNF 50; D= WHF 25: TNF 75; E= WHF 0: TNF 100.) were prepared with wheat flour as control and the total phenol content, proximate composition, functional and pasting properties were evaluated. The total phenol content ranged from 0.026 – 0.077mg/100g and results of fat and crude fibre ranged from 1.50 – 27.24% and 1.67 – 12.33% respectively, showing significant difference as the level of substitution with tigernut flour increases. Results showed increase in water absorption capacity and solubility which ranged from 0.91 – 1.60g/g and 1.43 – 1.51g/g respectively. A peak viscosity of 194.74RVU which was significantly ($p \geq 0.05$) different from other flour blends was observed in sample A (wheat flour), with sample E having the least peak viscosity. Trough viscosity (Hold period) ranged from 15.66RVU (Sample E) to 97.54RVU (Sample A). Peak time decreased from 6.06mins (Sample A) to 5mins (Sample E) as the level of tigernut flour increased.

Keywords: Tigernut, total phenol, pasting and functional properties

Introduction

Tigernut is an annual or perennial plant, growing to 90 cm tall, with solitary stems growing from a tuber. Nutritional composition of tigernut tubers shows some distinctive characteristics between other tubers and nuts (Sánchez-Zapata *et al*., 2012) [35]. The nuts are valued for their nutritious starch content (29.9%), dietary fibre (8.81 g/100g), and also contains appreciable amounts of minerals such as Sodium, Calcium, Potassium, Magnesium, Zinc and traces of Copper. It has been known that tigernut contain higher essential amino acids than those proposed in the protein standard by WHO/FAO for satisfying adult needs (Bosch *et al*., 2005) [18]. Also, the nut was found to be rich in myristic acid, oleic acid, linoleic acid. Tigernut tuber contains some digestive enzymes such as lipase, catalase and amylase which help to reduce indigestion, diarrhoea, and flatulence. It is rich in vital vitamins which includes vitamin B1 (which aids in balancing the central nervous system and helps to encourage the body to adapt to stress) (David, 2005) [19].

Wheat has been shown to be low in essential amino acid like lysine (Olapade and Oluwole 2013) [30] and tigernut flour for health reasons have been shown to be an alternative for dietetics, as it is gluten free (perfect for people who cannot take gluten in their diet), has a natural sugar (which makes it a good option for diabetics), it contains a high fibre content, thus making it a healthy alternative to wheat flour. Applications of flours in the food industry is primarily governed by the functional properties, investigation of these properties is necessary to know their utilization (Falade and Okafor 2015) [23]. Functional properties have been defined as the essential physicochemical properties of foods that reflect the complex interactions between the structure's molecular conformation, compositions, and physicochemical properties of food components with the nature of the environment and conditions in which these are measured and associated. Functional characteristics are required to possibly help to predict and precisely evaluate how new proteins, fat, carbohydrates (starch and sugars), and fibre may behave in specific food systems as well as demonstrate if such can be used to stimulate or replace conventional protein, fat, (Suresh and Samsher, 2013 [39]; Kaur and Singh, 2006 [27]; Siddiq *et al*., 2009) [37] carbohydrates (starch and sugars), and fibre.

Functional properties also describe the behavior of ingredients during preparation and cooking, as well as how they affect the finished food products in terms of how it looks, feels and tastes. Functional properties include Swelling capacity, water absorption capacity, oil absorption capacity, Foam capacity, Foam stability, Bulk density, among others. The functional property of a food is characterized by the structure, quality, texture, nutritional value, acceptability, and (or) appearance of the food product.

Pasting properties refer to the changes that occur in food as a result of the application of heat in the presence of water. These changes affect the texture, stability and digestibility of the product, and this depends on the rigidity of starch which affects the granule Swelling potentials and the amount of amylose leaching out in solution. The starch granule contains amylose and amylopectin which make up about 98-99% of the starch dry weight. At the same starch to water ratio, different starch gives different pasting properties (Copland *et al*., 2009). The size and shape of starch granule depends on the botanical source and processing conditions. Amylopectin starches tend to be more regular in shape when compared with high amylose starches (Jayakody and Hoover, 2008) [26]. During heating, the increase in viscosity of starch water system occurs as a result of swollen granules and the decrease during further heating at high temperature is caused by weakening, disintegration and disruption of gelatinized granules

(Hagenimana and Ding, 2005) [24]. When majority of the granules are fully swollen, peak viscosity occurs.
The goal of this study is to formulate a composite flour and evaluate the nutrient content, bioactive compound, pasting and functional properties of the flour in order to determine their application in food processing.

Materials and methods

1. Source of Material

Mature yellow variety Tiger nut were purchased from the market in Port Harcourt, Nigeria. The Rapid Visco Analyzer (RVA) model 3C, Newport Scientific PTV Ltd, Sydney was used for pasting properties.

1.1 Preparation of Tigernut flour

Tiger-nut were sorted to remove extraneous and damaged tubers, and washed. This was then dried in an electric oven at 60°C for 6 hours The dried tigernut were milled to fine flour with a milling machine and sieved to pass through a 250µm aperture and packaged

2. Chemical Analysis

2.1 Determination of Proximate Composition

The Proximate composition of Moisture, Crude protein, Total ash, ether extract was determined using A.O.A.C methods (2006). Crude fibre was determined by A.O.A.C. method (2012). The Clegg Anthrone method as described by Osborne and Voogt (1978) was used in determining Total carbohydrate.

2.2 Total phenolic content

The Total phenolic content was determined using spectroscopic method as described by Ainesworth and Gillespie, (2007) [9]. This was prepared by mixing 1mL plant extracts (1mg/mL) of 10% Folin-Ciocalteu's reagent dissolved in 13ml of deionized water followed by the addition of 5mL of 7% Na_2CO_3 solution, allowed to mixed thoroughly and kept in the dark room temperature for 2hours. A blank solution was also prepared and absorbance was read at 760nm. Mean value of triplicate samples of absorbance were obtained. Total phenolic content was determined by extrapolating calibration line which was constructed as gallic acid equivalent (mg GAE) per gram of the dried sample.

$$\text{Phenol content mg/100g (TAE)} = \frac{\text{Conc .obtained in mg per litre x Vol of sample x DF}}{Wt\ of\ sample}$$

DF: Dilution factor. If not diluted, then DF = 1

2.3 Determination of Pasting Properties

Pasting properties of the flour blends were determined using the Rapid Visco Analyzer (RVA Model 3c, Newport Scientific PTY Ltd, Sydney) as described by Sanni *et al*., (2004) [36]. Five (5) grams of samples were accurately weighed into a weighing vessel, 25ml of distilled water was dispersed into a new test canister. Samples were transferred onto the water surface of the canister after which the paddle was placed into the canister. The blade was vigorously joggled up and down through the sample ten times or more until no flour lumps remained either on the water surface or the paddle. The paddle was properly centred into the canister and the measurement cycle initiated. Peak viscosity (RVA), Peak time (min), Peak temperature (℃), Trough (RVU), pasting temperature (℃) and final viscosity (RVU) were read on the instrument while breakdown and setback viscosities (RVU) were calculated.

3 Determination of functional properties

3.1 Foam capacity and foam stability

The foam capacity and stability were determined using the method described by Narayana and Narasinga & Rao (1982) [28]. Two grams of flour sample was added to 50 ml distilled water at 30 ± 2°C in a 100 ml measuring cylinder. The suspension was mixed and properly shaken to foam and the volume of the foam after 30 s was recorded. The Foam capacity was expressed as a percentage increase in volume. The foam volume was recorded 1 h after whipping to determine the Foam Stability as a percentage of the initial foam volume. The result obtained was calculated as stated below.

$$\text{Foam capacity (\%)} = \frac{\text{volume after shaking(whipping)} - \text{volume before shaping (whipping)}}{\text{Volume before shaking (whipping)}} \times 100$$

$$Foam\ Stability = \frac{Foam\ volume\ after\ time\ "t"}{Initial\ Volume} \times 100$$

3.2 Water absorption capacity

Water Absorption Capacity was determined in accordance with the method described by Onwuka (2005) [31]. One (1g) of the flour sample was weighed into a 15 ml centrifuge tube and suspended in 10 ml of water. It was shaken on a platform tube rocker for one minute at room temperature. The sample was allowed to stand for 30 min and centrifuged at 1200 x g for 30 min. The volume of free water was read directly from the centrifuge tube.

3.3 Oil absorption capacity (OAC)

The method described by Onwuka (2005) [31] was used in determining water absorption capacity. One gram of the flour was mixed with 10 ml refined corn oil in a centrifuge tube and allowed to stand at room temperature (30 °C) for 1 hr. It was centrifuged at 1600 r.p.m for 20 min. The volume of free oil was recorded and decanted. Fat absorption capacity was expressed as ml of oil bound by 100 g dried flour.

$$WAC\ (\%) = \frac{\text{Amount of water added} - \text{Free water Weight of sample}}{Sample\ Weight \times Density\ of\ Water} \times 100$$

3.4 Bulk density

Bulk density was determined using AOAC (2012). Briefly, five grams of the flour was added to a 20 mL graduated measuring cylinder. The cylinder was tap gently until the sample was closely packed. The volume occupied by the sample was noted and the bulk density (g/cm3) was expressed as weight(g) of flour divided by flour volume (cm3).

$$Bulk\ density = \frac{\text{sample Wt after tapping} - \text{sample Wt before tapping}}{volume\ before\ tapping}$$

3.5 Swelling power and solubility

Swelling power and Solubility were determined as described by Ayo *et al*., (2015) [15]. One gram(1 g) of the flour was mixed with 10 ml of distilled water in a centrifuge tube and heated to 80°C and held for 30 min with continuous shaking. The heated suspension was centrifuged at 1000 r.p.m for 15 min. The weight of the supernatant and the sediment was taken.

Calculations

$$\text{Swelling capacity } (g/g) = \frac{Weight\ of\ sediment}{Weight\ of\ sample}$$

$$Solubility\ index\ (\%) = \frac{Weight\ of\ supernatant}{Weight\ of\ sample} \times 100$$

4. Statistical analysis

The experiment will be laid out in a Complete Randomized Design (CRD), with 5 treatments. Composite flour of wheat and Tigernut (A= WHF 100: TNF 0; B= WHF 75: TNF 25; C= WHF 50: TNF 50; D= WHF 25: TNF 75; E= WHF 0: TNF 100.) Each treatment will be replicated twice. Data collected was analyzed using Analysis of Variance and means separated by Duncan Multiple Range Test at 5% degree of probability

Results

The result of the total phenol content shown in Table 1 revealed a range of 0.026 to 0.077g/100g of sample. The result showed that samples B to E were not significantly different, however there was increasing amounts of total phenol as the level of substitution with moringa seed flour increased.

Table 1: Total phenol content

Sample	Sample weight	Absorbance	Concentration	Phenol
A	1.005	0.36 ± 0.015^{d}	26.16 ± 0.87^{a}	0.026 ± 0.001^{ab}
B	1.003	0.76 ± 0.067^{c}	49.17 ± 3.97^{b}	0.049 ± 0.004^{a}
C	1.005	1.00 ± 0.15^{b}	56.45 ± 0.62^{b}	0.057 ± 0.0007^{a}
D	1.004	0.87 ± 0.10^{bc}	60.31 ± 0.94^{c}	0.06 ± 0.0014^{a}
E	1.004	1.24 ± 0.001^{a}	77.07 ± 1.99^{d}	0.077 ± 0.0014^{a}

Values are Mean ± Standard deviation. Means with different superscripts within a column are significantly different ($p \leq 0.05$). Keys: A= WHF 100: TNF 0; B= WHF 75: TNF 25; C= WHF 50: TNF 50; D= WHF 25: TNF 75; E= WHF 0: TNF 100. WHF: Wheat flour TNF: Tiger-nut flour

The results of proximate composition (Table 2) of the composite flour showed that moisture content ranged from 5.39 to 9.65% with sample A containing wheat flour being significantly higher ($p<0.05$) than all other samples. The result indicates a decreasing value of moisture content with Increase in the level of substitution with tiger-nut flour. Total ash content of the various treatment ranged from 0.59 to 1.64% with sample A (wheat flour) being significantly higher ($p<0.05$).

Table 2. Proximate composition (%)

Sample	moisture	Ash	Fat	Crude protein	Crude fibre	Carbohydrate
A	9.65 ± 1.34^{a}	1.64 ± 0.19^{a}	1.50 ± 0.71^{e}	21.83 ± 1.23^{a}	1.67 ± 0.00^{d}	63.71 ± 0.41^{b}
B	8.62 ± 0.07^{ab}	1.24 ± 0.13^{d}	7.69 ± 1.29^{d}	13.50 ± 0.00^{b}	2.82 ± 0.71^{c}	66.13 ± 0.52^{a}
C	7.57 ± 0.15^{bc}	1.05 ± 0.07^{bc}	14.05 ± 0.74^{c}	9.19 ± 0.00^{b}	6.16 ± 0.00^{c}	61.98 ± 0.65^{ab}
D	7.45 ± 0.57^{c}	0.75 ± 0.07^{b}	19.83 ± 1.45^{b}	6.99 ± 0.00^{c}	7.76 ± 0.25^{b}	57.22 ± 0.95^{c}
E	5.39 ± 0.35^{d}	0.59 ± 0.07^{cd}	27.24 ± 1.29^{a}	6.13 ± 0.00^{c}	12.33 ± 0.00^{a}	48.32 ± 1.56^{d}

Values are Mean ± Standard deviation. Means with different superscripts within a column are significantly different ($p \leq 0.05$) Keys: A= WHF 100: TNF 0; B= WHF 75: TNF 25; C= WHF 50: TNF 50; D= WHF 25: TNF 75; E= WHF 0: TNF 100. WHF: Wheat flour TNF: Tiger-nut flour

Results showed that reduction in the quantity of wheat flour led to a reduction in ash content as sample E containing tiger-nut flour only had a value of 0.59% for ash. Fat content or ether extract values showed that sample E (tiger-nut flour) had a significantly higher value of 27.24% than sample A (wheat flour) which contains 1.50%. Improvements in fat content was obtained by increasing the treatment combination with tiger-nut flour. The crude protein content showed that sample A (wheat flour) had significantly ($p<0.05$) higher amounts of crude protein 23.83% than others. This shows that the tiger-nut is not a good source of protein substitution in flour.

However, the crude fibre content improved significantly from 1.67% to 12.33% for sample E. The crude fibre content results indicate that tiger-nut flour is a good source of dietary fibre compared to wheat flour only. Total Carbohydrate content ranged from 48.32 to 63.71% with sample A (wheat flour) having a significantly higher value than sample E.

Table 3: Functional Properties of Composite Wheat- Tiger flour

Blends	Water absorption (g/g)	Oil absorption (g/g)	Solubility (%)	Swelling power (g/g)	Bulk density(g/ml)	
					Pack density	Loose density
A	0.95 ± 0.021^{cd}	1.47 ± 0.12^{a}	21.41±0.42c	10.48 ± 0.37^{a}	0.84 ± 0.00^{a}	0.50 ± 0.014^{a}
B	0.91 ± 0.04^{d}	1.43 ± 0.13^{a}	21.77±1.09b	9.18 ± 0.62^{b}	0.81 ± 0.007^{b}	0.45 ± 0.00^{b}
C	1.03 ± 0.02^{c}	1.49 ± 0.04^{a}	24.52 ± 2.20^{a}	8.60 ± 0.03^{bc}	0.79 ± 0.007^{b}	0.44 ± 0.007^{bc}
D	1.27 ± 0.06^{b}	1.51 ± 0.09^{a}	25.36 ± 1.45^{a}	7.99 ± 0.05^{cd}	0.75 ± 0.007^{c}	0.42 ± 0.014^{c}
E	1.60 ± 0.06^{a}	1.51 ± 0.01^{a}	25.55 ± 0.14^{a}	7.31 ± 0.02^{d}	0.72 ± 0.014^{d}	0.41 ± 0.014^{c}

Values are Mean ± Standard deviation. Means with different superscripts within a column are significantly different ($p \leq 0.05$). Keys: A= WHF 100: TNF 0; B= WHF 75: TNF 25; C= WHF 50: TNF 50; D= WHF 25: TNF 75; E= WHF 0: TNF 100. WHF: Wheat flour, TNF: Tiger-nut flour

The functional properties of composite wheat tiger-nut flour are shown in Table 3.
Results obtained indicated that there was significant difference ($p \leq 0.05$) in water absorption capacity of samples, with sample E being the highest with a value of 1.60g. The oil absorption capacity ranged from 1.43 to 1.51 for sample E. The result indicated that there was no significant difference ($p \leq 0.05$) between all the samples. The water solubility percentage value ranged from 21.77 to 25.55% for sample E, the results indicated that there was no significant difference between the flour blends (C to E). The swelling Power of the flours ranged from 7.31 to 10.48g/g with sample A which contains wheat flour having a high significant difference ($p<0.05$) when compared to other samples. The bulk density values ranged from 0.72to 0.84g/ml for pack density with sample A (wheat flour) having a value of 0.84g/ml being significantly different ($p<0.05$) from other samples. However, increase in addition of tiger-nut flour affected pack density. The loose density of the flour ranged from 0.41 to 0.50g/ml with sample A having a significantly higher value than the other samples.

Table 4: Pasting properties of Composite Wheat-Tiger-nut flour

Sample	Peak 1 (RVU)	Trough (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback (RVU)	Peak Time (min)	Pasting Temperature (°C)
A	194.74±20.56^{a}	97.54±13.14^{a}	97.25±7.42^{a}	192.42±19.80^{a}	94.87±6.65^{a}	6.06±0.09^{a}	92.03±0.035^{a}
B	138.87±4.66^{b}	71.13±48.37^{ab}	67.75±9.72^{b}	142.34±4.83^{b}	71.21±0.41^{b}	5.60±0.18^{b}	86.37±0.035^{a}
C	86.00±5.90^{c}	52.25±3.42^{ab}	33.75±2.47^{c}	95.42±0.83^{c}	43.16±1.65^{c}	5.36±0.05^{b}	84.00±1.061^{ab}
D	44.83±1.06^{d}	30.29±1.00^{b}	14.54±0.06^{d}	53.79±1.24^{d}	23.50±0.24^{d}	5.04±0.05^{c}	84.37±5.197^{b}
E	19.00±0.11^{e}	15.66±0.23^{b}	3.34±0.12e	24.33±0.71^{e}	8.66±0.47^{e}	5.00±0.00^{c}	86.85±2.899^{b}

Values are Mean ± Standard deviation. Means with different superscripts within a column are significantly different ($p \leq 0.05$) Keys: A= WHF 100: TNF 0; B= WHF 75: TNF 25; C= WHF 50: TNF 50; D= WHF 25: TNF 75: E= WHF 0: TNF 100, WHF: Wheat flour, TNF: Tiger-nut flour, RVU: Rapid Viscous Units.

The pasting properties of the flour blends is shown in Table 4. and the values of the pasting properties differed according to different flour blends from sample A to E. The peak viscosity for sample A (wheat flour) was the highest 194.74RVU. Other values were 138.87, 86.00, 44.83, 19.00RVU for sample B, C, D and sample E respectively. Result showed that all the samples were significantly different.
The trough characteristics of the flours showed that sample A (97.54) and sample E (15.66) are significantly different. Increasing the level of flour substitution with tiger nut flour led to reduction in values obtained. The breakdown viscosity value ranged from 3.34 to 97.54 RVU. The result indicated that as the level of substitution of tiger-nut increased, the breakdown viscosity of the flour decreased. The results of the final viscosity ranged from 24.33 to 192.42RVU. The result showed that there was a significant difference between sample A (wheat flour) and sample E (tiger-nut flour). The setback viscosity of the flours showed that sample A had the highest setback viscosity of 94.87RVU and sample E was the lowest with a value of 8.66RVU.
The peak time (time taken for the flour to reach peak viscosity in minutes) showed that sample E had the shortest time of 5.00mins, while sample A has the longest time to reach peak viscosity with a time of 6.06mins.
The pasting temperature of the flours ranged from 84.00 for sample C to 92.03°C for sample A which was the highest temperature. The result showed that there was no significant different between sample A, B, C and also no significant difference between sample C, D and E.

Discussion

Table 2 shows the proximate composition of the flour samples. It shows that moisture content ranged from 5.39 to 9.65 for sample A, with highest value recorded for sample A, this implies that this sample maybe more susceptible to spoilage and sample E having the lowest moisture content value. Moisture content decreased with increase in tigernut flour substitution. The low moisture content in tigernut flour has a positive effect on shelf stability, moisture leads to spoilage of product due to oxidation reactions and microbial growth. High moisture content of food product promoted microbial growth as well as insect growth which affects the quality of the flour. The ash content of the samples decreased with increase in ratio of tigernut flour in the samples. The value ranged from 0.59 to 1.64 for sample A. A similar result was reported by (Abiodun *et al.,* 2017) on wheat-tigernut chin chin. Ash content is an indication of the mineral content of a food (Ndife *et al.,* 2015). The high value for sample A means that sample A has a rich source of mineral.
There was significant increase in the fat content as ratio of tigerrnut increases from 1.64 to 27.24%. This maybe as a result of high amount of fat in tigernut as reported by Bamishaiye and Bamisaiye (2011). Defatting tigernut before utilization or processing to flour may yield better results. A similar result was reported by (Ade-Omowaye *et al.*, 2008) [6]. The crude protein content of the sample ranged from 21.83 to 6.13% for sample E. This is higher than the range of 7.66 to 11.58% obtained by (Abiodun *et al.*, 2017) for wheat-tigernut chin chin. The crude protein content decreased as more tigernut flour was incorporated into wheat flour, this indicates that tigernut flour has a low protein content as compared to wheat flour and is not a food source of protein substitution in flour. Crude fibre content increased with substitution of tigernut flour to the samples which is similar to the findings of Ezeocha and Onwuneme (2016) that increase in tigernut flour increased crude fibre content, the value ranged from 1.67 for sample A to 12.33 for sample E. The result showed that there was a significant difference between sample A and sample E. Dietary fibre intake has numerous health benefits, it reduces the risk of developing diseases such as stroke, hypertension, diabetes, obesity, coronary heart disease and certain gastrointestinal disorders. Also, increased intake of dietary fibre increases serum lipid concentration, improves glucose control in diabetes, helps in weight loss and also appears to improve immune function (Anderson *et al.,* 2009) [8]. Carbohydrate content value ranged from 48.32 to 63.71% for sample A.

With sample A (wheat flour) having the highest value. A similar result was reported by (Ade-Omowaye *et al.,* 2008) [6] with values which ranged from 54.7 to 68.7%. Carbohydrate content decreases with increasing substitution of tigernut flour. Carbohydrate content was significantly higher in sample A than other samples indicating low carbohydrate content of tigernut flour. Carbohydrate could be an important source of energy to consumers (Appiah *et al.,* 2011) [12]. Table 3 shows the Functional properties of the flour samples which are properties that determine the suitability of a food material for a particular purpose or they are those parameters that determine the end use of food materials for various food products.

Water absorption capacity (WAC) which defines the rate at which each of the sample absorbed water, increased with increase in tigernut flour addition. Result showed that there was an increase in WAC as tigernut flour ratio was increased. Sample E which has the value 1.60g/g had the highest value. This value reduced gradually as ratio of wheat flour increases 0.95g/g. High WAC is due to loose structure of starch polymers while low values show the compactness of the particles (Adebowale *et al*, 2005) [3, 5]. According to Ayele and Nip (1994) [14] increase in WAC implies increase in the digestibility of the product and WAC is important in dough consistency and baking quality of products (Amandikwa *et al.,* 2015). It is a useful indication of whether flour can be incorporated into aqueous food formulation, especially those involving dough handling. Better water absorption capacity suggests better performance in texture. Results of Oil absorption capacity (OAC) ranged from 1.29 to 1.51g/g for sample E. Sample E which contains 100% tigernut flour had the highest value and OAC is important since it acts as flavour retainer and increases mouth feel of foods (Aremu *et al*, 2008) [13]. The lower OAC of tigernut flour might be due to low hydrophobic proteins which show superior binding of lipids. The Solubility value ranged from 21.41- 25.55% for the sample A and E respectively. The results showed increased solubility of the starch with increase in the proportion of tigernut flour in the formulation and this implies an increase in the dextrinization of starch. The results obtained were higher than those reported by Twum *et al*, (2015) [40] who investigated Tiger, maize and soybean composite flour. The Swelling power of the composite flour showed decreasing values with increase in substitution with Tigernut flour. This could be as a result of differences in chain length and distribution of starch (Bainbridge *et al*, 1996) [16].

Bulk density is a measure of heaviness of a flour sample. The pack density ranged from 0.72 to 0.84g/ml and loose density ranged from 0.41 to 0.50g/ml, the bulk density is seen as a reflection of the load the sample can carry if allowed to rest directly on one another. Particle size and starch content of food or product affects bulk density. Bulk density is important in raw material handling and packaging as well as application in wet processing in the food industry (Adebowale et.al, 2008 [4]; Ajanaku *et al*, 2012) [7]. There was a decrease in swelling power/capacity as the tigernut flour ratio was increased. There was a significant ($p<0.05$) difference between sample A and sample E. As water absorption capacity increases, swelling capacity decreases and the product becomes more readily digestible.

Pasting properties of the flour samples were presented in Table 4. Pasting properties are properties which relate to the ability of a food product to act in paste like manner (Otegbayo *et, al.,* 2006) [32]. Peak viscosity is the highest viscosity attained by starch during heating in water or soon after heating. It is ability of a starch to swell freely before their physical breakdown (Sanni *et al.,* 2004) [36]. Peak viscosity ranged from 19.00 to 194.74 RVU for sample A. Peak viscosity of the flour decreased with increase in substitution of tigernut flour in the blends, sample A had the highest peak viscosity with the value of 194.74RVU. Result showed that there was significant difference between all the sample. High peak viscosity shows the suitability of the blends for products requiring high gel strength and elasticity. High starch damage results in high peak viscosity, Ribotta *et al*, (2007) [34]. This implies that Sample E will not be appropriate in product formulations that will require high gel strength and elasticity due to its low peak viscosity value of 19.00RVU. Trough viscosity which is the minimum viscosity value measures the ability of paste to withstand breakdown during cooling and the values obtained ranged between 15.66 RVU for sample E and 97.54RVU for sample A. The breakdown viscosity is the measure of the susceptibility of the cooked starch sample to disintegration. It ranged from 3.34RVU for sample E to 97.25RVU for sample A. The result obtained showed that all the samples were significantly different. Breakdown viscosity is related to the degree of swelling of the starch granules during heating as well as Stability of starches under hot conditions. Amylose content is believed to have a marked influence on the breakdown viscosity (measure of susceptibility of cooked starch granule to disintegration) Venema, (2004) [41] and Adebowale *et al.,* 2005) [3, 5], reported that the higher the breakdown in viscosity, the lower the ability of the sample to withstand heating and shear stress during cooking.

During cooling, reassociation between starch molecules especially amylose will result in the formation of a gel structure and therefore the viscosity will increase to a final viscosity (Ragaae *et al*., 2006) [33]. The final viscosity gives an idea of the ability of a product to gel after cooking. The final viscosity of sample A was recorded as the highest value of 192.42 RVU and the lowest value of 24.33 RVU for sample E. The final viscosity is used to define the particular quality of starch and indicates the stability of cooked paste in actual use. It also indicates the stability to form various paste or gel after cooling.

The setback value of the blends ranged between 8.66 to 94.87 RVU. Higher setback results in lower retrogradation during cooling of products Ikegwu, (2010) [25], and a low setback value is an indication of softer crumb. This implies that such composite blends when used in bakery should produce products with soft crumb, which is a desirable attribute in cakes.

Pasting time is the measure of time the cooking time. The pasting time ranged from 5.00 to 6.06 minutes. A similar result was reported by Enyinnaya *et al*, (2010) [21].

The pasting temperature is a measure of the minimum temperature required to cook a given food sample. The pasting temperature ranged from 86.85°C flour sample E and 92.03 °C. A similar result was reported by Enyinnaya *et al,* (2010). Flour blends with higher pasting temperature may not be recommended for certain products due to high cost of energy (Abioye *et al*., 2011) [2].

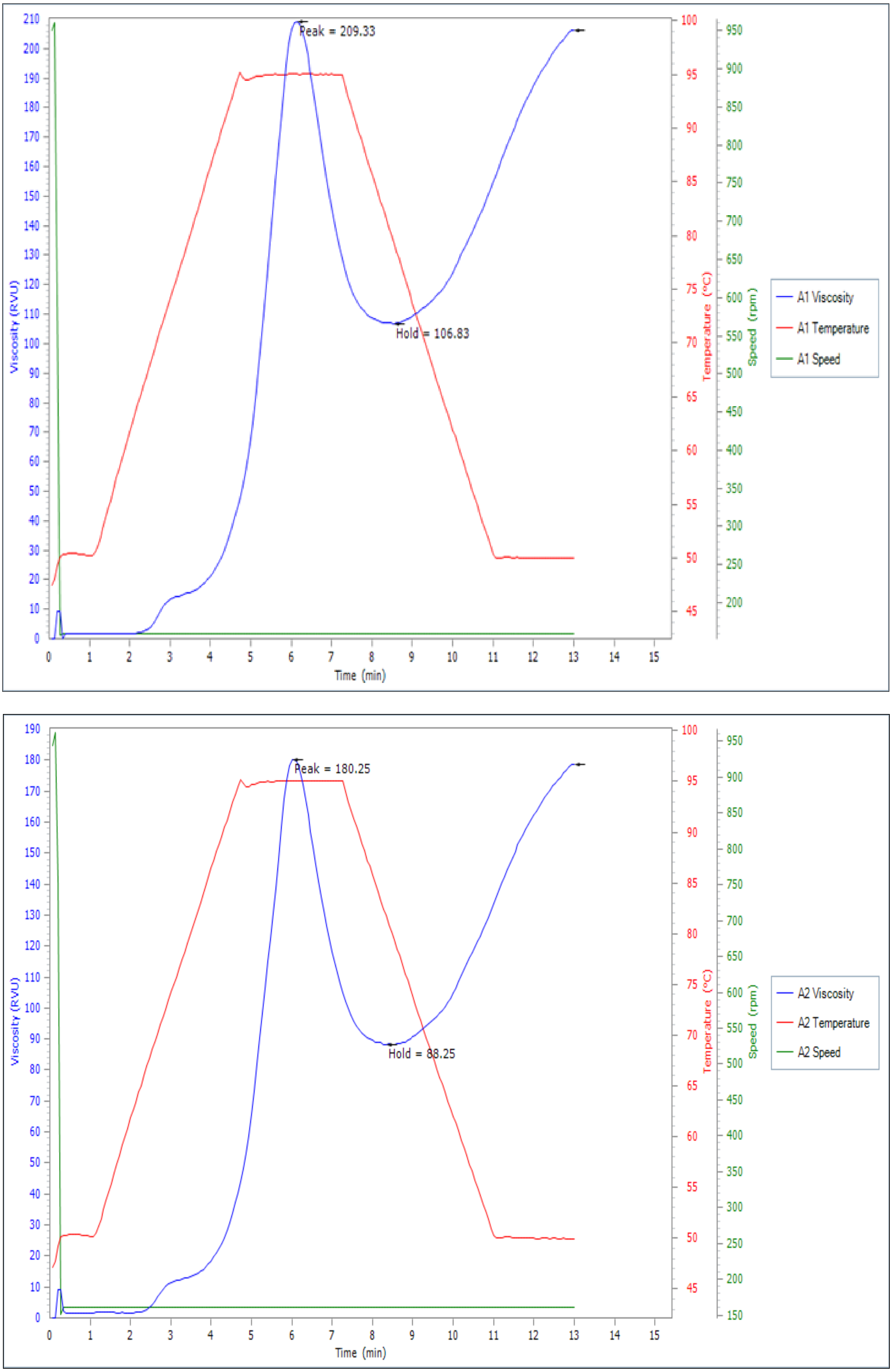


Fig 1: Showing pasting curves for sample A

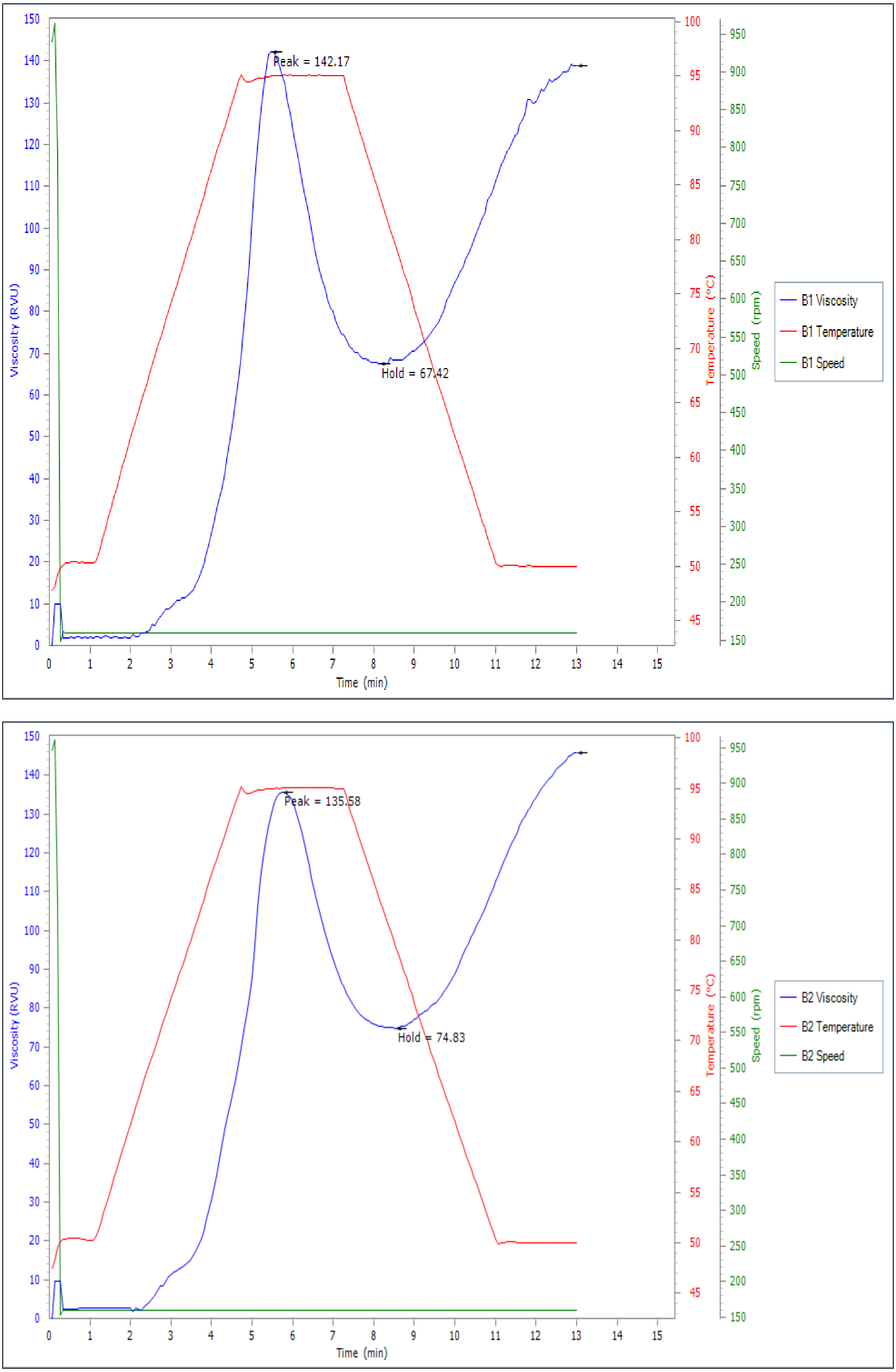
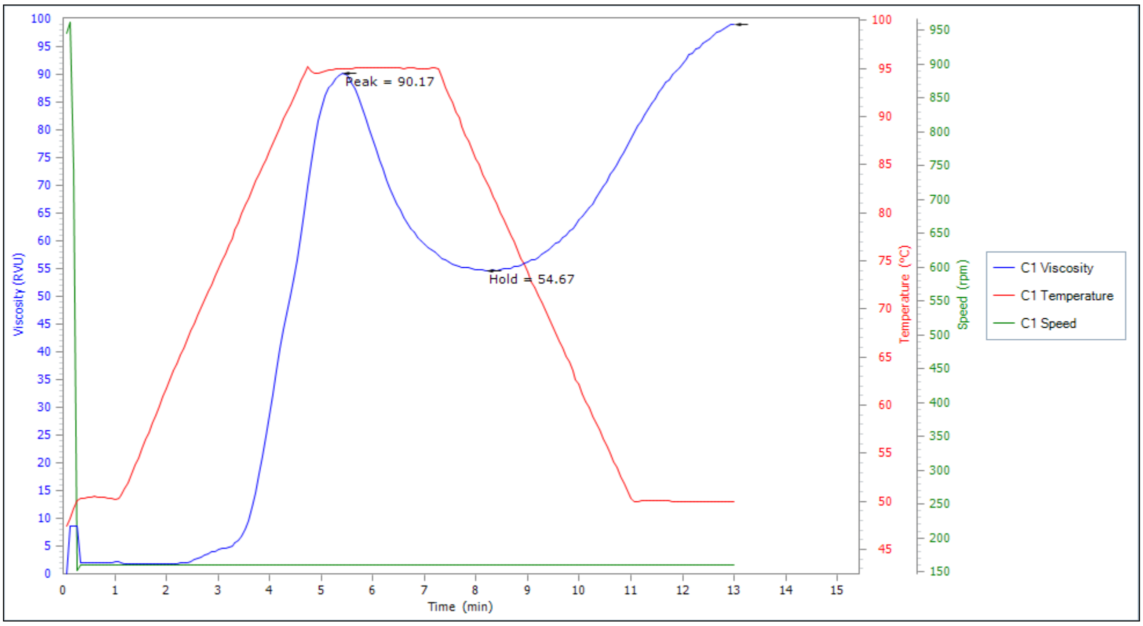


Fig 2: Showing pasting curves for sample B



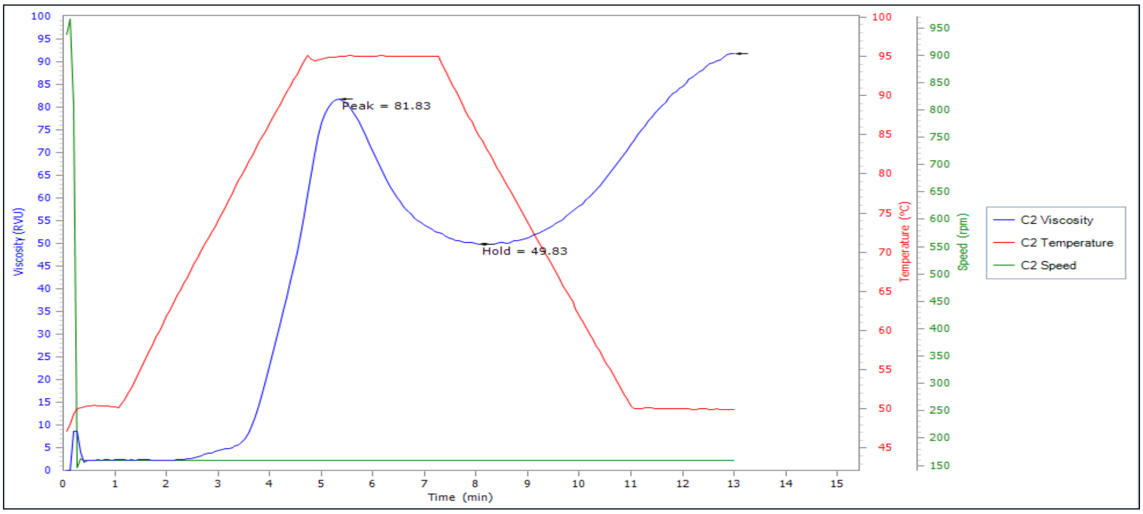
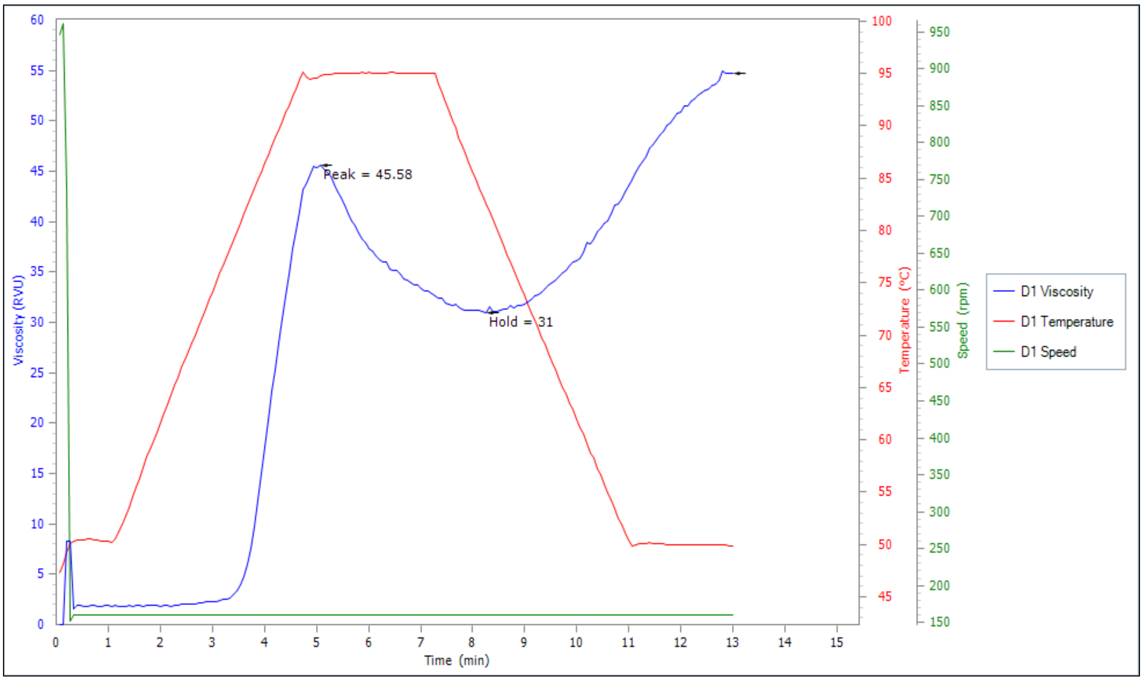


Fig 3: Showing pasting curves for sample C



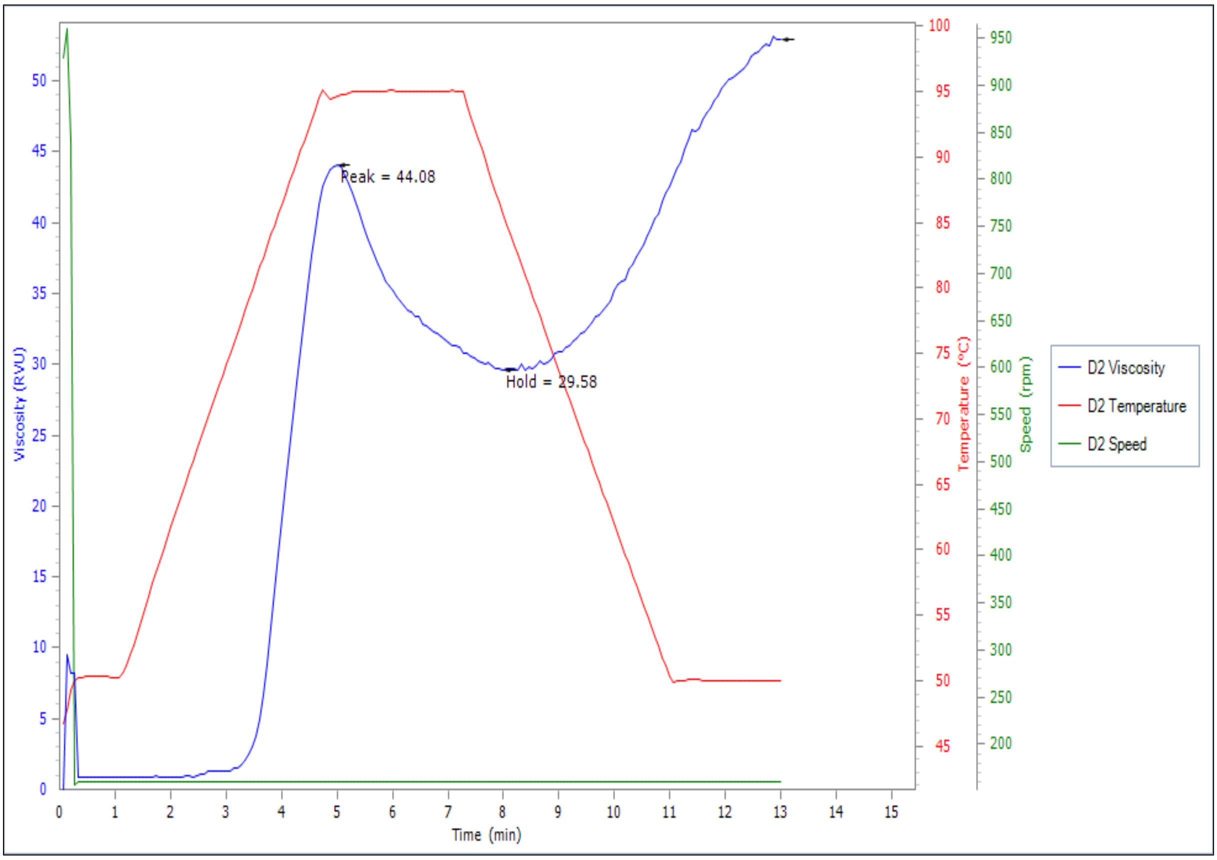
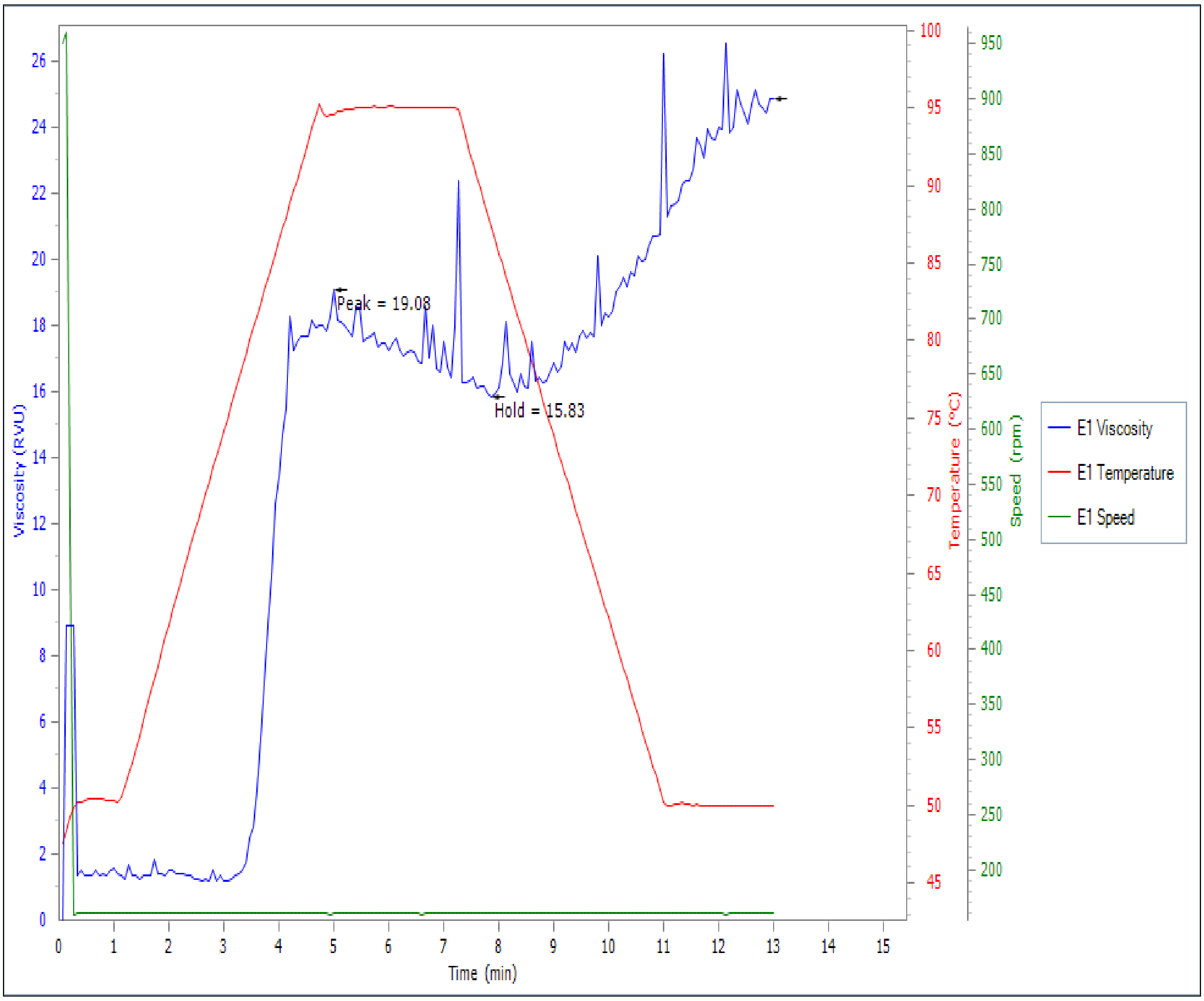


Fig 4: Showing pasting curves for sample for sample D



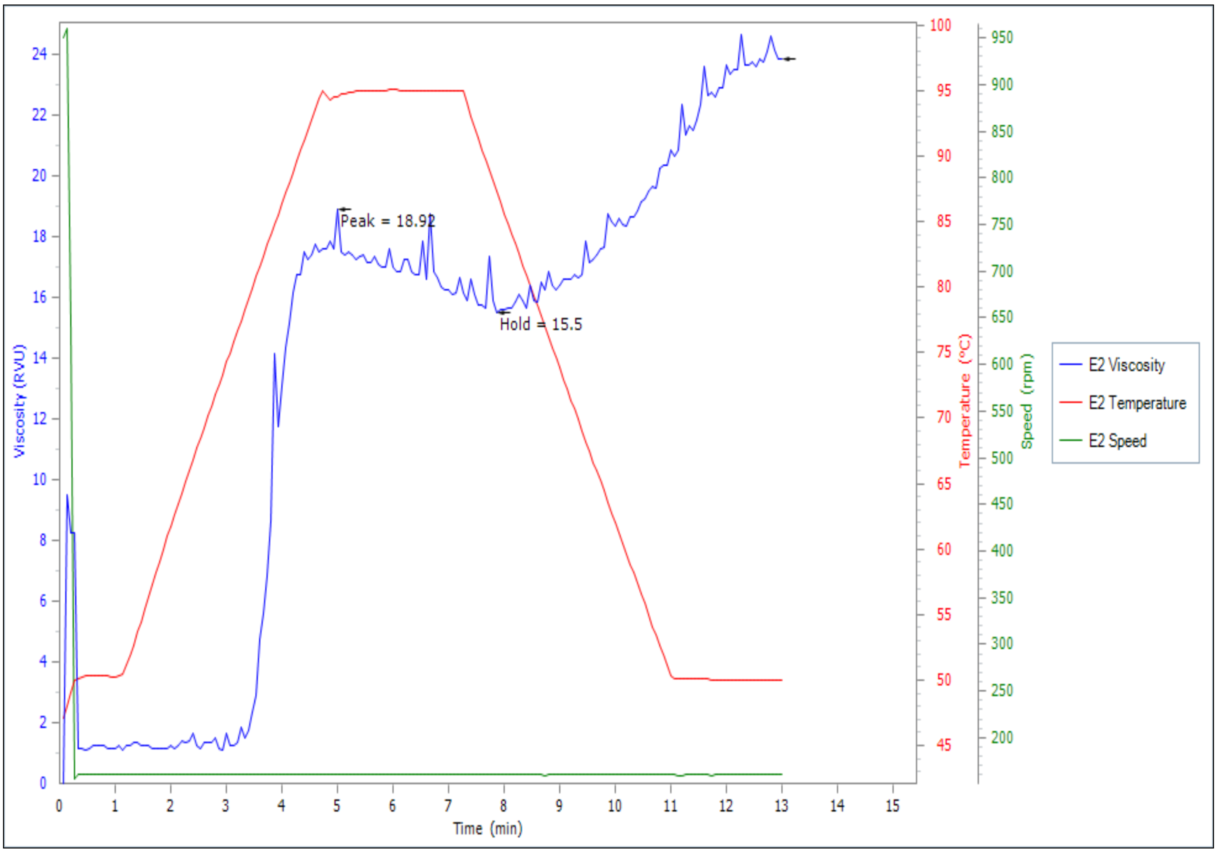


Fig 5: Showing pasting curves for sample E

Conclusion

The moisture content of the various flour formulations was reduced with increased substitution levels with tigernut flour. Reduction in moisture content value of flour has a direct positive effect on the shelf stability of the flour. Also, increasing the substitution levels of wheat flour with tigernut flour increased the dietary fibre content of the composite. This increase in dietary fibre can be associated with numerous potential health benefits such weight loss, immune function and glucose control in diabetics.

Author Contribution

Author VCW designed the experiment and Author carried out the research work, with both authors working the manuscript.

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Declaration of Competing interest: The authors declare that there is no conflict of interest.

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