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EVALUATION OF FUNCTIONAL, PASTING AND RHEOLOGICAL POTENTIALS OF COMPOSITE FLOUR FROM COWPEA, SWEET POTATO AND DATE FRUIT

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ABSTRACT

This work investigated the quality characteristics of composite flour from blends of cowpea, sweet potato, and date fruit for potential applications in food system. Cowpea, potato and date fruit were processed into flours and formulated into composite flours in the ratios A - 30:40:30; B – 20:50:30; C - 40:30:30; D – 35:35:30; E – 50:20:30 for cowpea, sweet potato, and date fruit, respectively. The formulated composite flours were evaluated for functional, pasting and rheological properties. The range of values obtained for bulk density (BD) water absorption capacity (WAC), oil absorption capacity (OAC), swelling capacity and dispersibility were 0.62 – 0.66g/ml, 148.07 – 217.02%, 162.68-258.76% 252.70 – 322.40% and 70.30 – 84.91% respectively. For pasting, peak, trough, breakdown, final, setback viscosities. peak time and pasting temperature were 12.80 – 55.34 RVU, 11.31 – 33.54 RUV, 1.20 – 2.25 RUV, 20.91 – 48. 03 RVU, 8.74 – 15.22 RVU, 4.32 – 7.07 min, 51.05 – 82.27 ^{o}C, respectively. There were significant ($p< 0.05$) difference in functional and pasting properties. The result of the functional properties showed that sample E had the highest in WAC, BD, OAC, swelling capacity and dispersibility while pasting properties showed that sample B had the highest peak, trough breakdown, final, setback viscosities and pasting temperature. The study showed that composite flour from cowpea, sweet potato, and date fruit could find applications in baked products, formulation of foods such as thick dough and soups.

Keywords: Cowpea, Sweet potato, Date fruit, Composite flour, Functional property, Pasting, Rheological property.

1 INTRODUCTION

The increasing demand for affordable, nutritious, and locally sourced food products has stimulated research into the development of composite flours from indigenous crops. Composite flour technology involves the blending of flours from different plant sources to improve nutritional quality, functional characteristics, and processing performance in food systems. In many developing countries, the high dependence on imported wheat has contributed to increased production costs and reduced affordability of wheat-based products. Consequently, there is growing interest in utilizing locally available crops such as cowpea, sweet potato, and date fruit as alternative raw materials for food formulation and product development (Noofarahizilah et al., 2014).

Cowpea (*Vigna unguiculata*) is a rich source of protein, dietary fibre, vitamins, and minerals. It also possesses important functional and rheological properties due to its starch, protein, and fibre composition, which influence viscosity, gelatinization, and retrogradation behaviour. The rheological properties of cowpea are viscoelastic in nature and are influenced by factors such as moisture content, temperature, and processing methods (Adebowale and Lawal 2019; Mekibeh et al., 2020). Sweet potato (*Ipomoea batatas*) is an important root crop valued for its high carbohydrate content, water-holding capacity, gelation, and thickening properties. Its starch exhibits desirable pasting characteristics such as peak viscosity, breakdown viscosity, and setback viscosity, which are essential in food processing applications (Abuthaher et al., 2020; Abdelfattah et al., 2021). Date fruit (*Phoenix dactylifera*) is a nutritious fruit rich in natural sugars, dietary fibre, minerals, and antioxidants. It serves as a natural sweetener and can improve the nutritional and sensory quality of composite flour products while reducing the need for refined sugar addition (Saeed et al., 2021). Despite the nutritional and health importance of cowpea, sweet potato, and date fruit, limited information exists on the functional, pasting, and rheological behaviour of their composite flour. Blending different flours has been identified as an effective strategy for improving flours qualities and potentials; consequently support food security and enhance value addition in the food industry.

This study is therefore justified because the utilization of cowpea, sweet potato, and date fruit in composite flour production could encourage the use of indigenous crops in food processing and product development. Understanding the functional, pasting, and rheological properties of this composite flour is essential in determining their suitability for various food applications.

2 METHODOLOGY

2.1 Source of raw material

Wholesome cowpea, date fruit, and fresh sweet potato roots were obtained from Eke Market Afikpo while date fruit was obtained from Kogi State.

2.2 Production of cowpea flour

Five hundred gram of cowpea grains were sorted washed with potable water (1:200, w/v) and soaked for 30 min. Thereafter it was drained using plastic sieve and manually dehulled with the aid of hand-rubbing. The dehulled cowpea seeds were dried in a hot air oven at 55 ^{o}C for 12 h. The dried seeds were milled using attrition mill and then sieved using stainless sieve of 212 µ mesh size. The obtained flour was packed in an air tight container for further use.

2.3 Production of Potato flour

Fresh potato was washed in excess potable water, peeled, manually diced using stainless steel knife, hot-water blanched for 5 min and oven dried at 55 ^{o}C for 18 h. The dried potato slices were milled using attrition mill and sieved using stainless sieve of 212 µ mesh size. The obtained flour was packed in an air tight container for further use.

2.4 Production of Date fruit flour

Date fruit was washed in excess potable water and oven dried at 55 ^{o}C for 6 h. The dried potato slices were milled using attrition mill and sieved using stainless sieve of 212 µ mesh size. The obtained flour was packed in an air tight container for further use.

2.5 Formulation of composite flour

Flours from cowpea, sweet potato, and date fruit were blended in ratios (Table 1), homogenized, and packed in an air tight container for further use.

Table 1: Blends formulation for composite flour from cowpea, sweet potato, and date fruit

Sample	Cowpea Flour (g)	Potato Flour (g)	Date fruit Flour (g)
A	30	40	30
B	20	50	30
C	40	30	30
D	35	35	30
E	50	20	30

2.6 Functional properties determinations

Swelling capacity, water absorption capacity, oil absorption capacity, and dispersibility were carried out as described by Otegbayo et al. (2013).

2.7 Pasting Properties

The pasting properties of the flour samples were determined using the rapid visco analyzer (RVA).

2.8 Statistical Analysis

The data obtained were subjected to one way analysis of variance (ANOVA) and the difference between mean was determined by Duncan multiple range test with the aid of SPSS version 22.0) software at 95% confident interval.

3 RESULTS AND DISCUSSION

3.1 Functional Property

The results of the functional property of the flour blends are presented in Table 1. The bulk density of the samples ranged from 0.62 – 0.66 g/ml. Sample B had the lowest (0.62 g/ml) bulk density while sample E had the highest (0.66 g/ml) bulk density. There were significant differences ($p< 0.05$) among the samples. The values reported in this work is slightly higher than the values 0.48-0.50 gl/ml reported by Adebayo-Oyetoro et al. (2016) on fermented cassava flour. Bulk density is affected by particle size and density of the flour (Udensi and Eke, 2000). As reported by Plaami (1997), bulk density is affected by the structural composition of the starch polymer; and thus could lead to low bulk density. High bulk density is desired in the flour for easy dispensability and paste thinning (Udensi and Eke, 2000). Also, the high bulk density is due to high amounts of crude fibre in the composite flour as explained by Singh et al. (1996).The water absorption capacity (WAC) of the samples ranged from 148.07 – 217.02%. Sample B had the lowest (148.07%) while sample E had the highest (217.02%) WAC. There were significant differences ($p<0.05$) among the samples. The value reported in this work is higher than the values 0.88 – 0.91% reported by Adebayo-Oyetoro et al. (2016) on fermented cassava flour. According to Oppong et al. (2015), dough made from composite flour absorbed more water. The findings of this study showed that both samples B and E could found applications baked products.

The oil absorption capacity of the samples ranged from 162.68 – 258.76%. Sample B had the lowest (162.68%) OAC, while sample E had the highest (258.76%). There were significant differences ($p< 0.05$) among the samples. The values reported in this study were higher than the values 39 to 53 % reported by Chinma et al. (2008) for some Nigerian cowpeas. The ability of the proteins in the flour blends to bind oil makes it useful in hydrophobic food systems.

Table 2: Functional properties of composite flour from cowpea, sweet potato, and date fruit

Parameter	A	B	C	D	E
Bulk density (g/ml)	$0.63±0.01^{ab}$	$0.62±0.01^{ab}$	$0.65±0.01^{a}$	$0.65±0.01^{a}$	$0.66±0.01^{a}$
WAC (%)	$151.09±0.11^{d}$	$148.07±0.11^{e}$	$196.17±2.02^{b}$	$175.34±0.59^{c}$	$217.02±1.00^{a}$
OAC %)	$166.00±1.59^{d}$	$162.68±1.56^{e}$	$228.88±0.11^{b}$	$205.69±0.83^{c}$	$258.76±0.28^{a}$
Swelling capacity (%)	$252.70±1.51^{e}$	$267.86±1.19^{d}$	$300.77±1.17^{b}$	$286.11±1.62^{c}$	$322.40±1.47^{a}$
Dispersibility (%)	$75.00±1.23^{b}$	$70.30±0.88^{c}$	$81.52±1.91^{a}$	$77.66±0.98^{b}$	$84.91±1.99^{a}$

Values are mean ± standard deviation. Means in the same column bearing different superscripts are significantly ($P< 0.05$) different. ; WAC - Water absorption capacity; OAC - Oil absorption capacity; A –30% Cowpea+40% Potato+ 30 % date fruit; B – 20% Cowpea,+50% Potato+30% date fruit; C - 40% Cowpea+30% Potato+30 % date fruit; D - 35% Cowpea+35% Potato+30 % date fruit; E - 50% Cowpea+20% Potato+30 % date fruit

The swelling capacity of the sample ranged from 252.70 – 322.40%. Sample A had the lowest (252.70%) while sample E had the highest (322.40%) swelling capacity. There were significant differences ($p< 0.05$) among the samples. The values reported in this work were higher than values 2.70 – 3.4% reported by Malomo et al., (2012) on yam flour enriched with soy flour. Swelling capacity of flour granules is an indication of the extent of associative forces within the granules.

The dispersibility of the samples ranged from 70.30 – 84.91%. Samples B had the lowest (70.30%) while sample E had the highest (84.91%) dispensability. There were significant differences ($p< 0.05$) among the samples. The value reported in this work is comparable to the values 73.30 – 77.50% reported by Olegbayo et al. (2013) on soy-enriched tapioca. The dispensability showed the reconstitution ability of the samples in water (Olegbayo et al., (2013). The high values of dispersibility obtained in this study indicated high degree of reconstitution to give a fine consistency dough during mixing.

3.2 Pasting properties

The pasting characteristics of the samples are presented in Table 2. Pasting characteristics of starch powder are important quality index in predicting the behaviour of starch paste during and after cooking so as to ascertain the stability of its gel.

The peak viscosity of the samples ranged from 12.80 – 55.34 RUV. Samples E had the lowest (12.80 RVU) while sample B had the highest (55.34 RVU). There were significant differences ($p< 0.05$) among the samples. The values reported in this work is lower to the values 285.00 – 455.58 RVU reported by Adebayo -Oyetoro et al. (2016) on fermented cassava flour. High peak viscosity is an indication of high starch content and it is related to the water binding capacity of starch (Adebayo -Oyetoro et al., 2016). The peak viscosity is indicative of the strength of pastes, which are formed from gelatinization during process in food applications.

The trough viscosity of the samples ranged from 11.31 -33.54 RUV. Sample E has the lowest (11.31 RUV) while sample A had the highest (33.54 RUV). There were significant differences ($p< 0.05$) among the samples. The values reported in this work is lower than the values 115.79 – 208.75 RVU reported by Adebayo-Oyetoro et al. (2016) for fermented cassava flour. The trough viscosity measures the ability of paste to withstand breakdown during cooling. The breakdown viscosity value is an index of the stability of starch (Adebayo-Oyetoro et al., 2016).

The breakdown viscosity of the samples ranged from 1.20 – 2.25 RVU. Sample C had the lowest (1.20 RVU) breakdown viscosity while samples B had the highest (2.25 RVU). There were significant differences ($p< 0.05$) among all the samples. The values reported in this work is lower than values of 91.08 – 184.5 RVU by Imoisi et al. (2020) on cassava flour. Breakdown viscosity gives insights into the stability of the paste and susceptibility of starch to shear force (Imoisi et al., 2020)

The final viscosity of the samples ranged from 20.91 -48.03 RUV. Sample E had the lowest (20.91 RVU) final viscosity while samples B had the highest (48.03 RVU). There were significant differences ($p< 0.05$) among all the samples. The values reported in this work were lower to the values 4.86.50 – 3500.50 RVU reported by Onyeneke (2019) on yellow cassava. The setback viscosity of the samples ranged from 8.74 – 15.22 RVU. Sample C had the lowest (8.74 RVU) setback viscosity while sample B had the highest (15.22 RVU) setback viscosity. There were significant differences ($p< 0.05$) among all the samples. Set back describes pasting curve phase after cooling and this phase involves re-association, retro gradation or re-ordering of starch molecules (Ajatta et al., 2016). High set back is associated with syneresis. This high value of setback viscosity showed that the composite flours could find applications in extruded snacks.

Table 3: Pasting properties of composite flour from cowpea, sweet potato, and date fruit

Parameter	A	B	C	D	E
Peak viscosity (RVU)	$35.19±0.24^{b}$	$55.34±0.72^{a}$	$25.40±0.17^{d}$	$30.97±0.21^{c}$	$12.80±0.17^{e}$
Trough viscosity (RVU)	$33.54±0.08^{a}$	$32.81±0.24^{a}$	$24.20±0.04^{c}$	$29.51±0.05^{b}$	$11.31±0.12^{d}$
Breakdown viscosity (RVU)	$1.66±0.18^{b}$	$2.25±0.48^{a}$	$1.20±0.13^{b}$	$1.46±0.16^{b}$	$1.49±0.05^{b}$
Final viscosity (RVU)	$45.65±0.12^{b}$	$48.03±0.36^{a}$	$32.94±0.08^{d}$	$40.17±0.11^{c}$	$20.91±0.11^{e}$
Setback viscosity (RVU)	$12.12±0.17^{a}$	$15.22±0.12^{a}$	$8.74±0.12^{c}$	$10.66±0.15^{b}$	$9.61±0.01^{bc}$
Peak time (min)	$5.99±0.86^{ab}$	$4.49±0.01^{c}$	$4.32±0.62^{c}$	$5.27±0.76^{b}$	$7.07±0.01^{a}$
Pasting temperature (oC)	$82.27±0.14^{a}$	$74.87±0.01^{b}$	$59.36±0.09^{d}$	$72.39±0.12^{c}$	$51.05±0.07^{e}$

Values are mean ± standard deviation. Means in the same column bearing different superscripts are significantly ($P< 0.05$) different. ; A –30% Cowpea+40% Potato+ 30 % date fruit; B – 20% Cowpea,+50% Potato+30% date fruit; C - 40% Cowpea+30% Potato+30 % date fruit; D - 35% Cowpea+35% Potato+30 % date fruit; E - 50% Cowpea+20% Potato+30 % date fruit

The peak time of the samples ranged from 4.32 – 7.07 min. Sample C had the lowest (4.32 min) peak time, while sample E had the highest peak time (7.07 min). The values reported in this work is comparable to the values (5.45 – 5.76 minutes) reported by Ajatta et al. (2016) on wheat, bread fruit and cassava composite. The peak time is a measure of the cooking time to attain peak viscosity. The pasting temperature of the samples ranged from 51.05 – 82.27 ^{o}C. Sample E had the lowest (51.05 ^{o}C) pasting temperature, while sample A had the highest (82.27 ^{o}C). The value reported in this work is comparable to the values 73.15 – 78.85o reported by Adebayo – Oyetoro et al. (2016) on fermented cassava flour. Pasting temperature give an indication of the gelatinization temperature required to cook.

3.3 Rheological property

The flow behaviour of the flour samples is shown in Figure 1. The shear rate ranged from 22-130 s^{-1} and the apparent viscosity of each flour blend decreased with increasing shear rate. Sample B had the highest (90 mPas) viscosity at 22 s^{-1} shear rate while sample E had the least (26 mPas) viscosity at 22 s^{-1}. The decrease in viscosity of the flour blends with increased shear rate followed the same trend. The result showed a shear thinning behaviour.

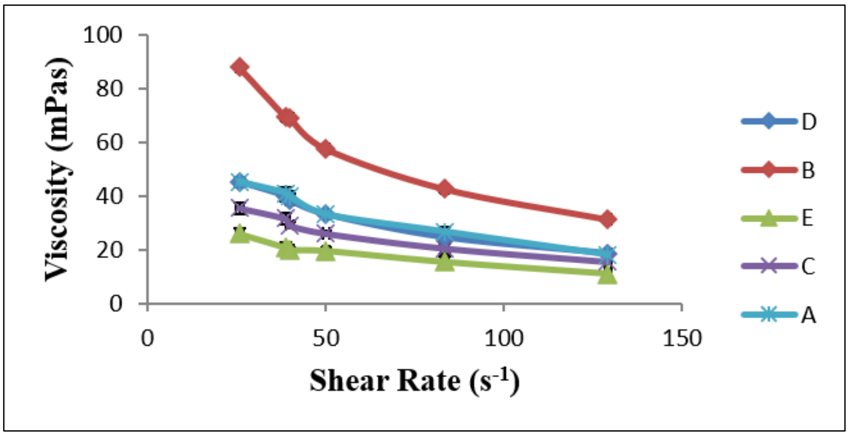

Figure 1: Rheological properties of composite flour from cowpea, sweet potato, and date fruit

4 CONCLUSION

The study showed formulation of composite flour from blends of cowpea, sweet potato, and date fruit and potential applications in food system. All the samples had good functional properties. The rheological properties showed that the flow of the flour blends was characterized by shear thinning effect. The study showed that composite flour from cowpea, sweet potato, and date fruit could find applications baked products, formulation of foods such as thick dough and soups.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare no conflicts of interest regarding this manuscript.

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