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Research Article

Functional Properties and Chemical Composition of Yellow and White Cassava Flours

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Abstract:

Functional and chemical composition of yellow and white cassava flour was studied. The cassava flours were labeled CW (white cassava flour) and CY (yellow cassava flour). The functional and chemical composition of the cassava flours were evaluated using standard analytical methods. The functional properties result of the cassava flours showed that bulk density ranged from 0.78-0.81 g/ml, water absorption capacity ranged from 8.33 to 8.50 g/g, oil absorption capacity from 8.20-8.43 g/g, emulsion capacity from 47.22-52.73 g/g, emulsion stability from 45.12-48.58 %, foaming capacity 11.48-14.27 %, foaming stability 45.55-49.73 %, swelling capacity 1.87-1.91 %, swelling index 1.46-1.51 %, dispersibility index 86.00-87.00 % and gelatinization temperature ranged from 64.00-71.00 oC. The chemical composition result of the cassava flour samples showed that total starch ranged from 59.63-60.76 %, amylose from 13.48-17.03 % and total carbohydrate from 79.37-82.44 %. The white cassava flour had better functional properties in respect to water absorption capacity, oil absorption capacity, foaming capacity, swelling capacity and swelling index while yellow cassava flour had good bulk density, emulsion capacity and stability, dispersibility and gelatinization temperature. In respect to chemical composition, yellow cassava flour had better total starch and total carbohydrate while amylose content was higher in white cassava flour. White cassava flour had better functional properties while yellow cassava flour had better chemical composition.

Key words: Amylose content; functional property; cassava flour; gelatinization temperature; total starch

Introduction

Cassava (*Manihot esculenta* Crantz) is perhaps one of the most widely grown because of its riches in carbohydrates especially starch which has a multiplicity of end users (International Institute of Tropical Agriculture, IITA) [1]. Nutritionally, cassava is a major source of dietary energy for low income consumers in many parts of tropical Africa including the major urban areas. Cassava (*Manihot esculenta* Crantz) stands out as a major diet for the Yoruba speaking ethnic in Nigeria as it is processed into varieties of fermented stable foods including *fufu, gari, pupuru, lafun* among others [2; 133-147]. Cassava flour had been used as a component of gluten-free composite with other cereals as major components and as hydrocolloids for several non-wheat-baked products and yogurts [3; 18-24].

Vitamin A biofortified cassava (a product of concerted efforts between HarvestPlus and BioCassavaPlus) is a transgenic, yellow-fleshed cassava cultivar which has been genetically modified to accumulate high levels of pro-vitamin A and other pro-vitamin A carotenoids either through traditional plant-breeding or bioengineering strategy [4; 1246-1269]. Biofortified cassava varieties could be used to tackle vitamin A deficiency [5; 18-27], an important public health problem in sub-Saharan Africa and in the world.

Vitamin A deficiency (VAD) remains a leading public health problem in the developing world, with its health consequences most apparent and severe among infants, young children and women of reproductive age. VAD is generally associated with decreased dietary intake of preformed vitamin A and its precursors, together with a high prevalence of infectious diseases, like measles, diarrhoea and respiratory tract infections (World Health Organization, WHO) [6]. According to West [7; 78-90], vitamin A deficiency is a major problem, in Africa. Nigeria sees a prevalence of vitamin A deficiency in about 20 % of pregnant women and 30 % of children under five; this problem can be overcome if yellow cassava that naturally contains high quantity of vitamin A is introduced into their diet. Hence, this study examines functional properties and carbohydrate composition of yellow and white cassava flours.

Materials and Methods

Source of Materials

White cassava tubers variety were purchased from Owode Market in Offa Local Government area of Kwara State while yellow cassava tubers variety were obtained from International Institute of Tropical Agriculture, Ibadan, Oyo State, Nigeria and transported immediately to the Food Processing Laboratory, Department of Food Technology, Federal Polytechnic, Offa, Kwara State, Nigeria.

Preparation of cassava flour

Fresh cassava roots (white and yellow varieties) were processed into flour using the method described by (International Institute of Tropical Agriculture, IITA) [1] with modification. The fresh cassava roots were weighed, peeled manually using stainless knife and then transferred to an electric grating machine which grated the cassava tubers to effect size reduction. The grated cassava roots were oven dried at 55±5 ^{o}C for 48 hr, milled using hammer mills and packed in high-density polyethylene bags.

Methods

Determination of functional properties of the maize varieties flour samples

The functional properties (bulk density, water and oil absorption capacity, emulsion activity and stability) of the maize varieties flours samples were determined as described by [8; 719-722]. Foaming capacity was evaluated using the method of [9; 1534-1538] while swelling power and solubility capacity were analyzed by the methods of [10; 105-110]. Dispersibility was determined by the methods described by [11; 1-7] while gelatinization temperature was determined by the method described by [12].

Determination of chemical composition of the maize varieties flour samples

The standard method described by Association of Official Analytical Chemists (AOAC) was used for chemical analysis such as total starch and amylose content of the samples [13] while carbohydrate content was determined by difference.

Statistical Analysis

Mean values of triplicate determinations of all the analyses were subjected to one way analysis of variance (ANOVA) to determine the significant difference and the means were separated using Duncan multiple range test at 95 % confidence level ($p<0.05$). Completely randomized design was used for the statistical analysis.

Results and Discussion

Results

Functional properties of yellow and white cassava flour

The result for the functional properties of yellow and white cassava flour was as presented in Table 1. Functional properties are described as those intrinsic physicochemical characteristics which may affect the behaviour of food systems during processing, storage and consumption such as solubility, formability, gelation and emulsification properties [14; 23-30]. The bulk density of the yellow and white cassava flour varied from 0.78 - 0.81 g/ml with white cassava variety (sample CW) having the highest bulk density (0.81 g/ml) while the least value for bulk density (0.78 g/ml) was observed in sample CY (yellow cassava flour). No significant difference ($p>0.05$) was observed between the bulk density of the cassava flour samples. Variation in bulk densities of the cassava flour was due to differences in their respective particle sizes. The values are slightly in agreement with 0.57 – 0.79 g/cm^3 reported for bulk density of different cassava flour studied by Hasmadi *et al.* (2020). Contrarily, the findings of [15; 326-347] for bulk density 39.60 – 80.02 % of *fufu* flour from different cassava varieties are higher than the values obtained in the current study. Ikujenlola *et al.* [16; 471-475] observes that knowledge of any product's bulk density is essential in choosing the suitable material for packaging. The smaller the bulk density value, the larger the amount of the product that can be packaged in each container volume, thus reducing the space occupied and the costs of packaging and transportation. Therefore, low bulk density of the cassava flour samples is an indication that larger quantity of cassava flour could be packaged in a container, thus, easing transportation.

Water absorption capacity of the flour yellow and white cassava flour samples ranged from 8.33 - 8.50 g/g with sample CW (white cassava flour) having the highest water absorption capacity (8.50 g/g) while the lowest water absorption capacity (8.33 g/g) was observed in sample yellow cassava flour (sample CY). Significant differences ($p<0.05$) were observed between the water absorption capacity of the cassava flours. The values are lower than 10.91 – 13.22 % reported for water absorption capacity of *garri* from white and yellow cassava roots studied by [17; 180-185], 111 – 123 % reported for water absorption capacity of maize-cassava adjuncts blends studied by [18; 15-29] and 115.28 – 164.25 % reported water absorption capacity of *fufu* flour from different cassava varieties researched by [14; 326-347].

The oil absorption capacity of the yellow and white cassava flour samples were of range 8.20 - 8.43 g/g with sample CW (white cassava flour) having the highest oil absorption capacity (8.43 g/g) while the least oil absorption capacity (8.20 g/g) was observed in sample yellow cassava flour (sample CY). Significant differences ($p<0.05$) were observed between the water absorption capacity of the cassava flours. The results are higher than 0.39 – 1.38 ml/g reported for oil absorption capacity of tigernut-cowpea flour blends studied by [19; 1-5] but lower than 96.45 – 148.65 % reported for oil absorption capacity of *okara* fortified plantain-sorghum flour blends researched by [20; 1-10]. Protein is a major chemical component that affects oil absorption capacity as it is composed of both hydrophilic and hydrophobic parts [21; 3681-3688]. Variation in values could be attributed to different materials used in the cited literatures.

The mean score values for the emulsion capacity of the yellow and white cassava flour samples ranged between 47.22 - 52.73 g/g with yellow cassava flour (sample CY) being the best in emulsion capacity (52.73 g/g) while the least value for emulsion capacity (46.94 g/g) was observed in sample CW (white cassava flour). There were significant variations ($p<0.05$) between the emulsion capacity of the cassava flour samples. The results are higher than 10.33 – 10.67 % reported for emulsion capacity of different varieties of cassava flour researched by [22; 991-999]. Kaushal *et al*. [23; 59-68] stated that the emulsion capacity of flour is influence by the hydrophobicity of protein. Contrarily, Chandra and Samsher [24; 4849-4852] reported that emulsion capacity is influenced by three main factors which are solubility, pH value and viscosity. High emulsion capacity of the cassava flour samples is an indication that the cassava flours could be an excellent emulsifier in food formulations [25; 1-8].

The emulsion stability of the yellow and white cassava flour samples varied from 45.12 - 48.58 % with yellow cassava flour (sample CY) significantly ($p<0.05$) having the highest emulsion stability (48.58 %) while the lowest value (45.12 %) was observed in white cassava flour (sample CW). The report of the current study conforms to 38.38 – 48.65 % reported for emulsion capacity of wheat flour, rice flour, green gram flour and potato flour blends researched by [21; 3681-3688]. Emulsion stability can be greatly increased when highly cohesive films are formed by the absorption of rigid globular protein molecules that are more resistant to mechanical deformation [21; 3681-3688] but lower than 55.00-62.5 % reported for emulsion stability of pigeon pea flour studied by [26; 742-753].

Foaming capacity is dependent on the ability of protein to adsorb rapidly at air - water interface during bubbling and undergo rapid conformational change and re-arrangement at the interface [27; 1461-1468]. The mean results for the foaming capacity of the yellow and white cassava flour samples were of range 11.48 – 14.27 %. White cassava flour (sample CW) had the highest foaming capacity (14.27 %) while the least value (11.48 %) for foaming capacity was observed in yellow cassava flour (sample CY). There were significant differences ($p<0.05$) between the foaming capacities of the cassava flour samples. The values are higher than 3.66 – 7.33 % reported for foam capacity of different cassava flour varieties researched by [22; 991-999] but lower than 22.00 – 71.50 % reported for foaming capacity of tigernut-cowpea flour blends studied by [19; 1-5].

Foam stability is important since the usefulness of whipping agents depends on their ability to maintain the whip as long as possible [25; 1-8]. The foam stability of the yellow and white cassava flour samples varied from 45.55 – 49.73 % with yellow cassava flour (sample CY) significantly ($p<0.05$) being the best in foam stability (49.73 %) while the lowest value (45.55 %) was observed in white cassava flour. The higher foam stability observed in yellow cassava flour (sample CY) is an indication that it will form stable foam longer than the white cassava flour sample (sample CW). The values are higher than 1.94 – 13.40 % reported for foam stability of wheat flour, rice flour, green gram flour and potato flour studied by [21; 3681-3688]. Contrarily, the foam stability of pigeon pea flours 235.0 – 410 % reported by [26; 742-753] are higher than those obtained in the current study.

The mean score values for the swelling capacity of the cassava flour samples differed significantly ($p<0.05$) with values ranging between 1.46 – 1.51 %.White cassava flour (sample CW) had the highest swelling capacity (1.51 %) while the least swelling capacity (1.46 %) was observed in yellow cassava flour (sample CY). Variation in swelling capacities of the cassava varieties flour samples could be attributed to difference sugar contents [27; 844-850]. Flours with both high-water absorption capacity holds large amounts of water during their preparation into gruels and thus become voluminous with a low energy and nutrient density while those with low capacities would provide a more nutrient-dense diet [27; 844-850].

The swelling index of the yellow and white cassava flour samples had significant variations ($p<0.05$) with values being of range 1.46 – 1.51 %. White cassava flour (sample CW) had the highest swelling index (1.51 %) while the least swelling index (1.46 %) was observed in yellow cassava flour. The swelling index values are lower than 2.15 –3.34 % reported for swelling index of *garri* from white and yellow cassava *garri* studied by [17; 180-185]. A good swelling capacity is indicator of high-quality flour, when it is soaked in hot water for reconstitution to form paste [28; 125-134].The low swelling index suggests that the starch granules of the cassava flour may have strong binding force and low amylose content [29; 2310-2315].

The dispersibility of any starchy food is a measure of its reconstitutability in water. The better the dispersibility of starchy food, the better it reconstitutes in water [30; 1-17]. The dispersibility index of the yellow and white cassava flour samples ranged from 86.00 – 87.00 % with yellow cassava flour (sample CY) having the highest value (87.00 %) while the least dispersibility index (86.00 %) was observed in white cassava flour (sample CW). The dispersibility index of the cassava flour samples differed significantly at 95 % confidence level. The result showed that the yellow cassava flour (sample CY) might reconstitute more appropriately in hot water without lumps during the preparation of dough because of their wide dispersibility compared with white cassava flour (sample CW). Awoyale *et al.* [30; 1-17] reported slightly similar values 74.00 –76.00 % for dispersibility of flours from different cassava varieties. However, the findings of the current study are higher than the dispersibility of 56–61 % for rotary-dried and flash-dried cassava flours [28; 125-134].

The mean results for the gelatinization temperature of the yellow and white cassava flour samples ranged from 64.00 – 71.00 ºC with yellow cassava flour (sample CY) having the highest value for gelatinization temperature (71.00 ºC) while the lowest gelatinization temperature (64.00 ºC) was observed in the white cassava flour (sample CW) sample. There were significant differences ($p<0.05$) between the gelatinization temperature of the cassava flour samples. The values are in line with 68.99 – 70.59 ºC reported for gelatinization temperature of different cassava flour varieties studied by [22; 991-999]. Similar observations have been reported for gelatinization temperature 60.99 – 71.00 ºC of two cassava starches and flours studied by [31; 19-25] and 67.50 – 8.10 ºC for gelatinization temperature of *garri* from white and yellow cassava roots. The molecular sizes of the cassava flour samples could influence their respective gelation temperature [32] (Onwuka, 2014).

Parameters	CW	CY
Bulk density (g/ml)	0.81±0.01^a	0.78±0.01^a
Water Absorption Capacity (g/g)	8.50±0.01^a	8.33±0.01^b
Oil Absorption Capacity (g/g)	8.43±0.01^a	8.20±0.01^b
Emulsion Capacity (%)	47.22±0.01^b	52.73±0.01^a
Emulsion Stability (%)	45.12±0.01^b	48.58±0.01^a
Foaming capacity (%)	14.27±0.01^a	11.48±0.01^b
Foam stability (%)	45.55±0.01^b	49.73±0.01^a
Swelling capacity (g/g)	1.91±0.01^a	1.87±0.01^b
Swelling index (g/g)	1.51±0.01^a	1.46±0.01^a
Dispersibility index (%)	86.00±0.01^b	87.00±0.01^a
Gelatinization Temperature (ºC)	64.00±0.01^b	71.00±0.01^a

Values are mean ± standard deviation. Data with different superscripts are significantly different at $p <0.05$. Sample CW = White cassava flour, Sample CY = Yellow cassava flour.

Table 1: Functional properties of yellow and white cassava flour

Chemical composition of yellow and white cassava flour

The result for the chemical composition of yellow and white cassava flour samples are shown in Table 2. The total starch contents of the cassava flour samples differed significantly with values ranging from 59.63 to 60.76 %. Yellow cassava flour (sample CY) had the highest total starch (60.76 %) while the least value (59.63 %) was observed in white cassava flour (sample CW). The results are lower than 84.75 – 90.59 % and 82.62 – 92.00 % for total starch contents of *garri* and *fufu* flour from different cassava varieties researched by [30; 1-17] as well as 82.9 – 87.0 % for total starch contents of *tuwo* made from maize and different cassava adjuncts studied by [18; 15-29].

The mean score values for the amylose contents of the cassava flour samples varied from 13.48 – 17.03 %. White cassava flour had the best amylose content (17.03 %) while the least amylose content (13.48 %) was observed in yellow cassava flour (sample CY). There were significant variations between the amylose contents of the cassava flour samples. The amylose contents are lower than 24.05 – 31.55 % reported for wheat-unripe plantain flour blends by [33; 30-42]. Higher level of amylose in the findings of [33; 30-42] was due to the level of plantain flour substitution in their biscuits. Amylose content is the underlying condition for categorizing starches into waxy, semi-waxy, regular and high amylose types when amylose content is 0 - 2 %, 3 - 15 %, 15 - 35 % and > 40 % of the total starch respectively [31; 19-25]. The amylose contents of these cassava flour samples can therefore be categorized as regular amylose.

The total carbohydrate contents of the cassava flour samples ranged between 79.37 - 82.44 % with sample CY (yellow cassava flour) being the best in total carbohydrate (82.44 %) while the least value (79.37 %) was observed in the white cassava flour (sample CW) sample. Significant differences ($p<0.05$) were observed between the total carbohydrate contents of the cassava flour samples. The report of the current study conforms to 84.01 – 90.95 % reported for total carbohydrate contents of maize-cassava adjuncts *tuwo* studied by [18; 15-29]. According to Oyewole and Afolami [35; 27-29] determined the starch content of cassava flour to be 77 – 78.7 % which are in agreement with the findings of this study while Karim et al. [36; 276-289] reported that cassava flour is normally rich in carbohydrate with starch as its main constituent.

Chemical composition (%)	CW	CY
Total starch	59.63 ± 0.01^b	60.76 ± 0.71^a
Amylose	17.03 ± 0.01^a	13.48 ± 0.01^b
Total carbohydrate	79.37 ± 0.01^b	82.44 ± 0.01^a

Values are mean ± standard deviation. Data with different superscripts are significantly different at $p < 0.05$. Sample CW = White cassava flour, Sample CY = Yellow cassava flour.

Table 2: Chemical composition of yellow and white cassava flour

Conclusion

White cassava flour had better water absorption capacity, oil absorption capacity, foaming capacity, swelling capacity and swelling index while yellow cassava flour was observed to have better bulk density, emulsion capacity and stability, dispersibility and gelatinization temperature. Yellow cassava flour had better total starch and total carbohydrate while amylose was higher in white cassava flour. Further studies are hereby recommended on the pasting, proximate composition and vitamin A content of the white and yellow cassava flour produced in this study for future product development.

Funding and conflict of interest

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