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Full Length Research Paper

Physico-chemical properties and micronutrients of whole wheat flour partially substituted with cashew apple powder

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Cashew apples were sorted after proper washing, sliced, dried at 65^{o}C and milled in a blender to produce cashew apple powder (CAP). The CAP were used at different levels of whole wheat flour substitution to produce composite flours in the ratio of 100:0, 90:10, 80:20, 75:25 and 0:100 whole wheat flour (WWF) and CAP respectively. The composite flour samples were further analyzed for their proximate composition, functional properties and some micronutrients using standard methods of analysis. Sample 0:100 (WWF: CAP) had the highest fibre and ash values (6.25%) and (2.70%) while sample 80:20 (WWF: CAP) had the least fibre (2.50%) and sample 100:0 (WWF: CAP) recorded the least ash content (1.99%). However, no significant difference (p>0.05) existed between the ash content of sample 90:10 (WWF: CAP) and 75:25 (WWF: CAP). In terms of protein content, the values decreased as the level of substitution increased from 10.54% for sample 100:0 (WWF: CAP) to 1.93% for sample 0:100 (WWF: CAP). Sample 75:25 had the highest fat content (11.40%) which did not differ significantly (p>0.05) with sample 90:10 (10.25%), however, sample 0:100 had the least fat content (4.60%). The samples showed no significant differences (p>0.05) in bulk density as the level of substitution increased except sample 0:100 which had 0.63kg/m^3, water absorption capacity(WAC) and oil absorption capacity (OAC) were highest in sample 90:10 (2.50g/ml) and (1.94g/ml) respectively. Sample 0:100 had the least WAC (1.20g/ml) and OAC (1.16g/ml). The 100% CAP had no values for foam capacity (14.25%) and gelation temperature (79^{o}C). The vit. C content of samples increased as the level of CAP substitution increased from 5.1(mg/100g) for sample 100:0 to 42.83(mg/100g) for sample 0:100. There were significant differences (p<0.05) in the iron and phosphorus contents of the flour samples with sample 90:10 having the highest values of 0.19% and 0.97% respectively.

Keywords: cashew apple powder, whole wheat flour, proximate, functional

INTRODUCTION

Cashew (*Anarcardium occidentale* L) is native to northeast Brazil and in the 16th century was introduced by Portuguese traders into Mozambique and coastal India as a soil retainer to stop erosion on the coast (Morton, 1987). The cashew was also used in Nigeria to control erosion because of the massive erosion problems in most part of the country (Ohler, 1988).

But in recent years, cashew is now of a considerable importance to Nigeria and other tropical countries. Apart from being a source of raw material for industries, its by-products are also important to researchers. The annual production of cashew apple in Nigeria is about 5.2million metric ones, most of them are left to rot in the field under the trees. Studies have shown that about 90% of cashew apple production being wasted annually in Nigeria. One of the causes of this is the short post-harvest life of the fruits coupled with the non-existence of industrialization capacity and short harvest period (Ogunjobi and Ogunwolu, 2010).

Fresh cashew apple are highly perishable, various

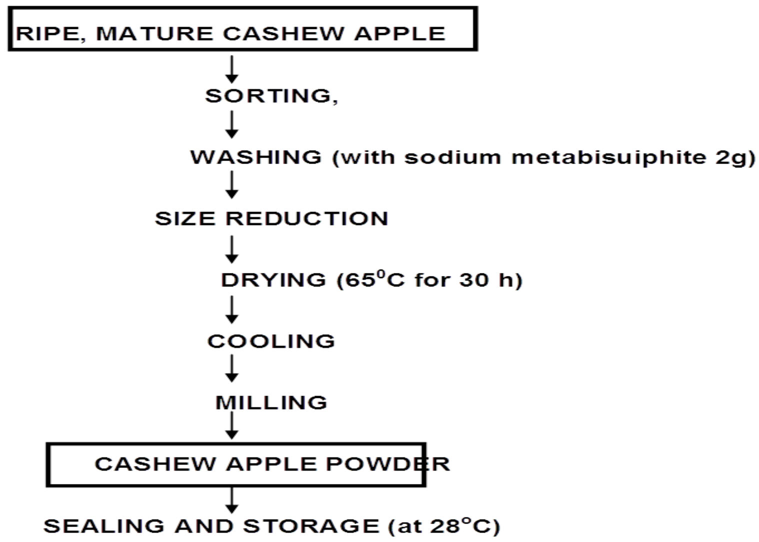

Figure 1: Flow chart for preparation of cashew apple powder

species of yeast and fungi causes spoilage after the first day at room temperature. Food technologists in India have found that good condition can be maintained for 5weeks at 32°F -35°F (0°-1.67°C) and relative humidity of 85% to 90% (Morton, 1987). Cashew is a valuable source of minerals and vitamins. It also contains protein, fibre and carbohydrates. Studies have shown the juice to contain five times as much vitamin C as citrus juice (Akinwale, 2000) and ten times as pineapple juice (Ohler, 1988). Cashew apple is used for curing scurry and diarrhea and is effective in preventing cholera. It is applied for the cure of neurological pain and rheumatism and is regarded as the first class sources of energy (http: //www. cashew apple (February, 2015). It is also reported to have anti-bacterial, anti-oxidant and anti-mutagenic effect (Cavalcante *et al*., 2005).

Drying of cashew apple into powder is an excellent alternative to increase its shelf life. It allows conversion of perishable materials into stabilized products by lowering the water activity into appropriate levels (Uchoa *et al*., 2009). This helps in preventing microbial spoilage and quality deterioration due to undesirable biochemical reactions.

Over the years, there had been an extensive research into the use of composite flour for baking aimed at curbing importation of wheat into Nigeria, whose produce of wheat is far below consumption level (Satin, 1988). Therefore, substitution of wheat flour with cashew apple powder will help achieve this aim and improve the nutritional quality of the composite flour for food uses.

The aim of this study was to evaluate the proximate, functional and some micronutrients of cashew apple powder-whole wheat flour samples.

MATERIALS AND METHODS

Source of raw material

Ripe, mature apple fruits (yellow variety) and whole wheat flour were obtained from Umuahia main market, Abia State for the preparation of the powder. The analyses were carried out at Food Science and Technology Department and National Root Crops Research Institute Laboratories, Umudike, Umuahia, Abia State, Nigeria and the reagents used were of analytical grade.

Preparation of Cashew apple Powder (CAP)

The ripe, mature fruits (yellow variety) were purchased and the nuts were detached from the apple manually. The apples were sorted, and washed with Sodium Metabisulphite Solution (2g in 100ml of water) to remove any contaminant present.

Cashew apples were cut into small pieces with stainless steel knife and placed in stainless trays for the drying process. The samples were oven dried at 65°C for 30h until the final moisture attained 6.73%.

After drying, the dried apple pieces were left to cool in a desiccator and then milled in a domestic blender (Phillips brand) at low velocity for 5 minutes to obtain a powder (figure1). The weight of the obtained cashew apple powder was recorded and the product immediately sealed in polyethylene bag and stored at room temperature (28°C) (Ogunjobi and Ogunwolu, 2010) with slight modifications.

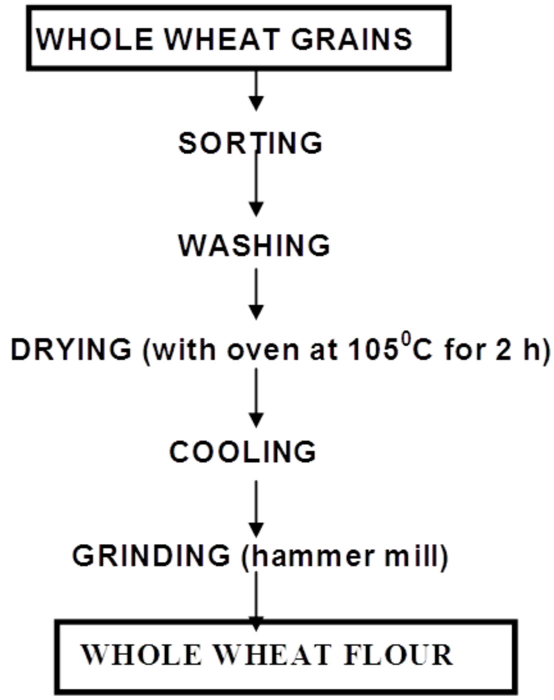

Figure 2: Flow chart for the preparation of whole wheat flour

Preparation of whole wheat flour

The wheat grains were sorted, washed and dried with an oven at 105^{0}C for 2h. The wheat was milled with a grinding machine to obtain whole wheat flour (figure 2).

Formulation of blends

The cashew apple powder and whole wheat flour were blended at different ratios to obtain six blends. The ratios were (whole wheat: cashew apple powder) 100.0, 90:10, 85:15, 80:20, 75:25, 0.100. Each blend was thoroughly mixed. (Oyewole et al., 1996).

Proximate Composition Determination

The whole wheat flour/cashew apple powder samples, were analyzed for moisture, ash, crude protein, crude fiber, fat according to the method described by A.O.A.C (1990); James (1995). The carbohydrate contents was determined by difference, a method reported by Onwuka (2005).The carbohydrate content was obtained by calculation having estimated all fractions by proximate analysis.

% Carbohydrate = 100 – (% moisture + % fat + % ash + % protein + % fibre).

Functional properties

The cashew apple powder- whole wheat blend were analyzed for bulk density, water /oil absorption capacity, foam capacity and foam stability, wettability, Gelatinization temperature according to Onwuka (2005).

Mineral determination

Determination of Calcium and Magnesium by Complexiometric Titration (Onwuka, 2005).

About 20ml portion of the extract was dispersed into conical flask and treated with pinches of the masking agents (hydroxylamine hydrochloride, sodium cyanide and sodium potassium ferrocyanide). The flask was shaken and the mixture dissolved. 20mls of ammonia buffer was added to it to raise the P^H to 10.00.the mixture was titrated against 0.02N EDTA solution using Erichrome Black T as indicator. A reagent blank was also titrated and titration in each case was done from deep red to a permanent blue end point. The titration value represents both Ca^2+ and Mg2+ in the test sample. The analysis was repeated to determine Ca^2+ alone in the test samples.

Titration of calcium alone was done in similarity with the above titration, 10% NaOH was used in place of

ammonia buffer and solechrome dark blue indicator in place of Erichrome black T.
The results were calculated as above

$$Ca/\ mg\ \ (mg/mg) = \frac{100}{W} \times \frac{T - B\ (N \times Ca/mg)}{va} \times vt$$

Where W=Weight of sample T = titre value of sample
B= Titre value of blank C = calcium equivalence
Mg =Magnesium equivalence
N=Normality of titrant (0.02N EDTA).

Determination of Phosphorus (James, 1995)

This was determined using molybdo vanadate colorimetric method. A measured volume of the dry ash (2mg) digest of the sample was dispersed into a 50ml volume flask. At the same time, the same volume of distilled water and standard p solution were measured into different flask to serve as reagent blank and standard respectively. Exactly 2mls of the phosphorus colour reagent (Molybdo vanadate solution) was added to each of the flask and allowed to stand at room temperature for 15 minutes. The content of each flask was diluted to the 50ml mark with distilled water and its absorbance was measured in a spectrophotometer at a wavelength of 540 with the reagent blank at zero.
Phosphorus content was calculated as follows:-

$$P\ (mg/100g) = \frac{100}{W} \times \frac{au}{As} \times \frac{C \times Vt}{Va}$$

Where W = weight of ashed sample
AU = absorbance of test sample
AS = absorbance of standard phosphorus solution
C = concentration of standard phosphorus solution
Vt = total extract volume
Va = volume of extract analyzed.

Determination of Iron

Iron was determined by Atomic Absorption Spectrophometer as reported by Onwuka (2005).

About 1.0g of the sample was digested with 20ml of acid mixture (650ml conc. HNO_3; 80ml perchloric acid, 20ml conc, H_2S04) in a digestion flask, the flask was heated until a clear digest was obtained. The digest was diluted with distilled water to 500ml mark. 91.0% W/V lithium chloride was added such that find solution was 10%.

Iron Standard

A stock solution containing 1000mg/mm of fe^{3+} ions was prepared from 1.0g of pure ion wire. The wire was dissolved in 100ml Conc. HNO_3 boiled on a water bath and diluted to 1000ml with distilled water from this stock solution, standard solutions of concentrations 0.0, 0.5, 1.0, 2.0 and 4.0 ppm were prepared.

Determination of Sodium

This was determined using flame photometry instrument as reported by Onwuka (2005).
Above 1.0g of the sample, was digested with 20ml of acid mixture (650ml of concentrated HNO_3, 80 ml of perchloric acid, 20ml of concentrated H_2SO4 and aliquots of the diluted clear digest taken for photometry using flame analyzer. Absorbance for sodium was read at 767nm. Sodium concentrations were obtained from the calibration curves obtained from the standards.

Vitamin C Determination

A.O.A.C (1990) methods of analysis was used in vitamin C determination.
Sample weight of 5g was homogenized with 20ml extractant (15ml meta-phosphoric acid, 40ml acetic acid, 450ml distilled water) for 3 minutes in a blender. The homogenate was filtered out under vacuum and used for titration.
20ml of vitamin extract was added into a 250ml conical flask, 30% 10ml potassium Iodide, and 4 drops of starch indicator was added. It was titrated against 0.0lm. copper sulphate pentahydrate ($CuS0_4.5H20$) solution until yellow colour appeared.
The blank was titrated.
Volume of $CuS0_4$ solution required to neutralise the vitamin C in 20ml extractant = sample titre – blank.
ml $CUS0_4$ = 0.88mg/L

$$\text{Ascorbic acid (vit.C(mg/100g)} = \frac{0.88}{1} \times \frac{100}{5} \times \frac{vf}{20} \times T$$

Vf = volume of the extractant
T= sample titre - blank titre

Statistical Analysis

Results were obtained in duplicates and the means were used. Data were analyzed using Analysis of variance (ANOVA) and statistical package for social science (SPSS) version 15.0. Significant difference between means was determined using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Proximate Composition of Whole Wheat Flour Partially Substituted with Cashew Apple Powder

Table 1 shows the proximate composition of whole wheat flour partially substituted with cashew apple powder. There were no significant differences (p> 0.05) in the moisture contents of the control (6.60%) and other samples except in WWF 80: CAP 20 (7.50%). The moisture content of the cashew apple powder (6.73%) was lower than 7.05% reported by Ogunjobi and Ogunwolu (2010).

Table 1: Proximate Composition of Whole Wheat Flour Partially Substituted With Cashew Apple Powder

SAMPLE WWF: CAP	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Crude fibre (%)	Carbohydrate (%)
100:0	$6.600^{bc}\pm0.14$	$5.400^{b}\pm0.14$	$10.540^{a}\pm0.01$	$1.990^{b}\pm0.01$	$3.200^{c}\pm0.14$	$72.770^{b}\pm0.84$
90:10	$6.250^{c}\pm0.35$	$10.250^{a}\pm3.18$	$5.180^{b}\pm0.01$	$2.000^{b}\pm0.00$	$3.000^{c}\pm0.00$	$73.320^{b}\pm3.54$
85:15	$7.250^{ab}\pm0.35$	$9.300^{a}\pm0.00$	$4.520^{c}\pm0.02$	$2.000^{b}\pm0.00$	$2.800^{c}\pm0.14$	$74.030^{b}\pm0.35$
80:20	$7.500^{a}\pm0.00$	$10.500^{a}\pm0.00$	$4.210^{d}\pm0.01$	$2.000^{b}\pm0.00$	$2.500^{c}\pm0.70$	$72.790^{b}\pm0.01$
75:25	$6.250^{c}\pm0.35$	$11.400^{a}\pm0.14$	$3.680^{e}\pm0.01$	$2.000^{b}\pm0.00$	$4.000^{b}\pm0.00$	$72.670^{b}\pm0.48$
0:100	$6.725^{bc}\pm0.03$	$4.600^{b}\pm 0.14$	$1.930^{f}\pm0.01$	$2.700^{a}\pm0.00$	$6.250^{a}\pm0.07$	$77.795^{a}\pm0.04$

Values are means of two duplicates.
Sample means with the same superscript along the columns are not significantly different at (P<0.05)
CAP= Cashew apple powder
WWF=Whole wheat flour
100:0=100% WWF, 90:10 = 90% whole wheat flour: 10% CAP 85:15 = 85%WWF: 15%CAP, 80:20 = 80%WWF: 20%CAP

This could be due to differenes in the period of drying.

There were significant differences (P<0.05) in the protein contents of all the samples. The protein content of the flour decreased as the level of cashew apple substitution increased. This could be adduced to the low level of protein in the cashew apple powder. The value of protein obtained (1.93%) was lower than that obtained by Ogunjobi and Ogunwolu (2010) which was 12.75% and Uchoa *et al*. (2009) which was 7.63%. This could be as a result of protein denaturation during drying. The cashew apple powder was dried longer than the drying time reported by Ogunjobi and Ogunwolu (2010) which was (12hours). The value of wheat 10.54% was comparable to the one obtained by Gernah *et al*. (2010) which was 10.30%.

There were significant differences (P<0.05) in the ash contents of the control (1.99%) and 100%CAP (2.70%). The ash content 2.70% (100% CAP), was comparable to that obtained by Ogunjobi and Ogunwolu (2010) (2.70%) but was higher than that obtained by Uchoa *et al*. (2009) which was 1.42%.

Significant differences (P<0.05) were observed between the sample substituted with 25% cashew apple powder (4.00%) and the control (3.200%).The cashew apple powder had the highest crude fibre contents (6.25%) which was higher than that reported by Ogunjobi and Ogunwolu (2010) which was 4.08%. This increase could be due to the fact that the fibre was not sieved out during processing.

Crude fibre does not contribute nutrients to the body, it adds bulk to food thus facilitating bowel movement (peristalsis) and preventing many gastro intestinal diseases in man. It is recommended that an average adult should consume about 18-32g fibre daily (Muller, 1988).

The carbohydrate content of the flour ranged from 72.67 – 77.80%. According to Messian (1992) the higher the protein, fat, ash content, the less the carbohydrate.

Functional properties of whole wheat flour partially substituted with cashew apple powder

It was observed in table 2 that the bulk density showed no significant differences (p>0.05) at all levels except in 0.630kg/\`m^3 (100% CAP). Low bulk density could be an advantage in the formulation of baby foods where high nutrient density of low bulk is desired. It is important in preparation of breakfast food and infant food formulation, bulk density help enhance both caloric and nutrient intake per quality served (Onimawo and Egbekun, 1998). This result has shown that 0.630kgm^3 will be the best in preparation of breakfast food and infant food formulation.

Significant differences (p<0.05) existed between the control (1.60g/ml) from 2.50g/ml and 1.20gml. Water absorption capacity represents the ability of a product to associate with water under condition where water is limiting (Giami and Bekebain, 1992) in order to improve its handling characteristics. Wolf and Cowman (1971) reported that water absorption capacity enables bakers to add more water to dough and so improves handling characteristics and maintain freshness. Iwe and Onadipo (2001) reported that increase in level of protein leads to increased capacity to hold or retain water. Sample 90:10 (WWF: CAP) with 2.50g/ml had the highest water absorption capacity which implied that it had higher affinity for water which is informed by its low moisture content (6.25g/ml). Significant differences (p<0.05) existed between the control (1.16g/ml) from, other samples. Sample 90:10 had the highest oil absorption capacity (1.94g/ml) due to less affinity to absorb more oil. The higher the oil in the flour, the lesser the affinity to absorb oil. Akubor (2003) reported that hydration is required to improve the handling characteristics of baked products.

Oil absorption capacity is the ability of the flour protein to physically bind fat by capillary attraction and it is of great importance since fat acts as flavour retainer and also increases the mouth fill of foods especially bread

Table 2: Functional properties of Whole Wheat Flour Partially Substituted with Cashew Apple Powder

SAMPLE WWF:CAP	BD Kg/m^{3}	WAC g/ml	OAC g/ml	Wettability (sec)	FC (%)	GT (^{o}C)
100:0	0.780^{a} ±0.01	1.600^{b}±0.28	1.160^{b}±0.12	27.250^{ab}±0.35	14.250±16.61	79.000±1.41
90:10	0.800^{a} ±0.00	2.500^{a}±2.12	1.940^{a}±0.53	24.840^{bc}±0.22	15.000±12.72	74.000±1.41
85:15	0.780^{a} ±0 00	1.500^{b}±0.14	1.520^{a}±0.38	26.960^{ab}±0.56	14.250±0.35	73.500±2.12
80:20	0.770^{a} ±0.01	1.500^{b}±0.70	1.520^{a}±0.63	25.480^{b}±0.67	12.000±14.14	67.00±2.82
75:25	0.770^{a} ±0.01	1.700^{b}±0.42	1.520^{a}±0.12	29.000^{a}±2.82	10.000±5.65	68.500±2.12
0:100	0.630^{b}±0.01	1.200^{b}±0.00	1.160^{b}±0.12	22.100^{c} ±0.14	NIL	NIL

Values are two means of replicates
Means in the same column with the same superscript are not significantly different (P<0.05)
WWF =Whole wheat flour
CAP = cashew apple powder
BD = bulk density
WAC = water absorption capacity, FC = foam capacity
OAC= oil absorption capacity GT= Gelation temperature
100:0=100%WWF, 0:100 = 100%CAP
90:10=90%WWF: 10%CAP
85:15=85%WWF: 15%CAP, 80:20=80%WWF: 20%CAP, 75:25=75%WWF: 25%CAP

and other baked foods (Kinsella, 1976, Hutton and Campbel, 1981).

The results showed that 22.1sec was the lowest wettability value recorded by 100% CAP which is significantly different (p<0.05) from the control. Okezie and Kosikowski (1981) reported that wettability is the time required by flour to reach its wetness. Wettability is important in reconstitution in water, it is related to the presence of soluble molecules, and lower wettability indicates better reconstitution properties (Colona *et al*., 1989).

Significant differences (P<0.05) existed among the samples. The control (79^{o}C) recorded the highest gelation temperature. Gelation is an important property which influences the texture of various kinds of foods such as moi-moi, agidi and soup (Udensi *et al*., 2001). Gelation also involves the swelling of starch granules, on heating (Odoemelam, 2005). The result showed that gelation temperature decreased as the level of cashew apple substitution increased. The cashew apple did not form gel due to absence of amylase and amylopectin which is responsible for gelation in flour.

Sample 90:10 (WWF: CAP) recorded the highest value 15.00% in form capacity. The formability of flours has been shown to be related to the amount of native proteins (Lin *et al*., 1974). Native protein gives higher foam stability than the denatured protein (Yasumatsu *et al*., 1972). Since proteins are heat labile, the reduced foam capacity of heat processed flours can be explained on the basis of protein denaturation, also since foam capacity is due to solubilized proteins (Narayana and Narasinga Rao, 1982). The result showed that the level of foam capacity decreased as the cashew apple substitution increased, the decreased foam capacity could be explained on the basis of smaller amount of solubilised protein available in the flour.

Foam Stability of Whole Wheat Flour partially Substituted with Cashew Apple Powder

From the result shown in figure 3, the control (at 15, 30, 60 and 120 seconds) had the highest value 99.22sec, 98.51sec, 97.49sec and 96.90sec respectively. There was a gradual reduction in foam stability as time increased. Foam stability is a colloidal system which forms by incorporating air (gas) into a soluble surface active agent (Ahmed and Schmidt, 1989).

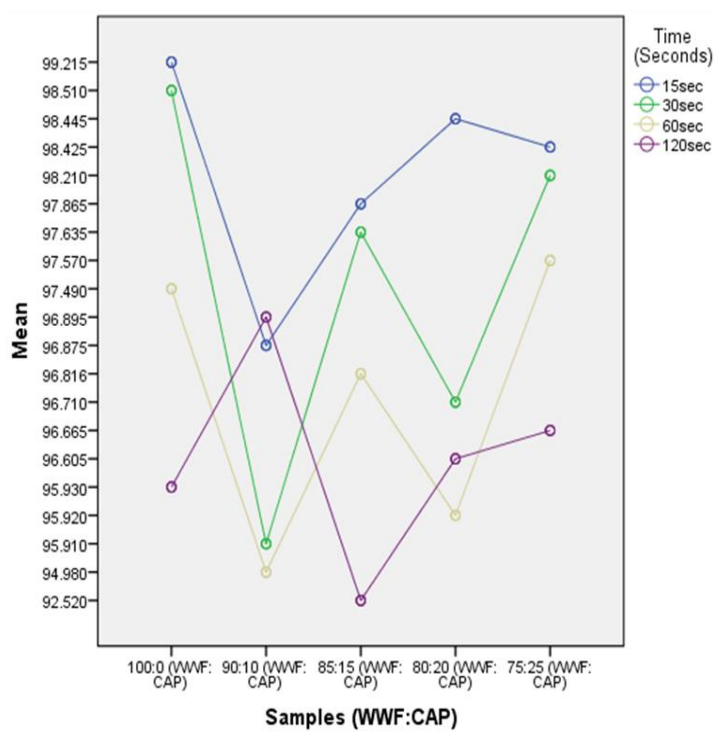

Figure 3: Foam stability of whole wheat flour partially substituted with cashew apple powder

Table 3: Mineral and Vitamin C Composition of Whole Wheat Flour Partially Substituted with Cashew Apple Powder

SAMPLE WWF: CAP	VITAMIN C (mg/100)	CALCIUM (%)	IRON (%)	PHOSPHORUS (%)	SODIUM (%)
100: 0	$5.100^{f}\pm0.14$	$1.200^{a}\pm0.00$	$0.007^{d}\pm0.00$	$0.700^{f}\pm0.00$	$0.008^{a}\pm0.00$
90:10	$10.570^{e}\pm0.01$	$0.660^{d}\pm0.00$	$0.190^{a}\pm0.00$	$0.970^{a}\pm0.01$	$0.008^{a}\pm0.00$
85:15	$12.370^{d}\pm0.01$	$0.685^{d}\pm0.00$	$0.010^{c}\pm0.00$	$0.895^{b}\pm0.00$	$0.006^{b}\pm0.00$
80:20	$14.675^{c}\pm0.00$	$0.900^{bc}\pm0.14$	$0.016^{b}\pm0.00$	$0.845^{c}\pm0.00$	$0.005^{b}\pm0.00$
75:25	$18.195^{b}\pm0.00$	$1.000^{b}\pm0.00$	$0.015^{b}\pm0.00$	$0.825^{d}\pm0.00$	$0.006^{ab}\pm0.00$
0:100	$42.825^{a}\pm0.03$	$0.800^{cd}\pm0.00$	$0.004^{a}\pm0.00$	$0.725^{e}\pm0.00$	$0.006^{b}\pm0.00$

Values are means of two replicates.
Sample means with the same superscript along the columns are not significantly different at (p<0.05).
CAP=Cashew apple powder WWF=Whole wheat flour.
100:0=100%WWF, 0:100=100%CAP
90:10=90%WWF: 10%CAP
85:15=85%WWF: 15%CAP
80:20=80%WWF: 20%CAP
75:25=75%WWF: 25%CAP

According to Lin et al. (1974) foam stability is important since the usefulness of whipping agent depend on their ability to maintain the whip as long as possible. According to Yasumatsu *et al*. (1972), native proteins give higher foam stability than denatured protein.

100% cashew apple powder did not record any value. This could be due to absence of native protein in the flour as the protein was denatured during processing.

Mineral and vitamin C composition of whole wheat flour partially substituted with cashew apple powder

There were significant differences (P<0.05) in the vitamin C contents of the flour. Addition of cashew apple powder increased the vitamin C content of whole wheat flour. The vitamin C content of the cashew apple powder was 42.83mg which was lower than the one obtained by Ogunjobi and Ogunwolu (2010), (52.60mg) but higher than that obtained by Ana Maria et al. (2009) which was 38.33mg. This could be as a result of prolonged drying. This result has shown that the Vitamin C content of whole wheat flour was improved by CAP substitution (Table 3).

The calcium content of the sample showed significant differences (p <0.05) in the samples. The level of calcium content of the flour increased as the level of cashew apple substitution increased. Cashew apple is a rich source of calcium which is important for the formation of strong bones and teeth.

Significant differences (p<0.05) exist in the iron content of the control (0.007%) and 0.004%. The level of iron decreased as the level of cashew apple powder substitution increased.

CONCLUSION

The study has shown that the supplementation of whole wheat flour with cashew apple powder has improved the overall quality of whole wheat flour which can make it to find useful application in baked products. It has been observed from the study that the fiber, ash and vitamin C contents of the whole wheat/ cashew apple powder were improved. The mineral contents were also improved especially for sample 90WWF:10CAP (whole wheat flour: cashew apple powder).

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