Croatian Journal of Food Science and Technology
journal homepage: www.ptfos.unios.hr/cjfst/

Original scientific paper

DOI: 10.17508/CJFST.2018.10.2.11

Chemical, functional, pasting and sensory properties of fried chips produced from cassava flour enriched with cowpea flour

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ARTICLE INFO

Article history:
Received: April 24, 2018
Accepted: July 23, 2018

Keywords:
high quality cassava flour,
cowpea flour,
composite flour,
fried chips,
chemical properties

ABSTRACT

Composite flours were produced from blends of high quality cassava flour and cowpea flour. The flours were blended in six different ratios: 75:25, 60:40, 50:50, 40:60, 25:75 and 100:0 which served as the control sample. The chemical, functional, pasting and sensory properties of the samples were determined. The results showed that significant differences (p<0.05) exist between the control sample and other blended samples. Sample 25:75 cassava-cowpea flour had the highest protein, ash, fat and crude fiber contents. Cyanide content of the composite flour decreased as the percentage of cowpea flour increased. The highest water absorption capacity, oil absorption capacity and swelling capacity were recorded for sample containing 100% cassava flour. Blending of high quality cassava flour with cowpea flour enhanced the nutritional quality of the cassava flour through increased protein and reduced cyanide contents.

Introduction

Cassava (*Manihot spp*) was described as a perennial woody shrub with an edible root which grows in tropical and subtropical areas of the world (IITA, 2009). Cassava roots are primarily sources of carbohydrates to both humans and animals, though they contain essential minerals and some vitamins such as calcium, vitamins B and C. However, their nutrient composition varies with cultivars, age of the harvested crop, soil conditions, climate and other environmental factors during cultivation. The consumption of cassava roots is popular among Africans and it was reported that nearly 80 kilograms of cassava per year was consumed per person in the continent (IITA, 2009). It was also estimated that 37% of dietary energy comes from cassava. Cassava roots are highly susceptible to deterioration after the harvest and this calls for their immediate processing in order to prevent postharvest losses associated with the roots. High quality cassava flour (HQCF) is simply unfermented cassava flour. The processing of fresh cassava roots into HQCF requires peeling, grating, dewatering, sieving and drying.

Cowpea is commonly cultivated legume in Nigeria and Africa in general. It is also cultivated in the sSouthern United States, Middle East, Asia and throughout the tropics and subtropics. The seed of cowpea is nutritious and highly palatable food source reported to contain high crude protein, carbohydrates, and fat (FAO, 2012). The protein in cowpea seed is rich in amino acids, particularly lysine and tryptophan, in comparison with cereal grain. However, it is deficient in methionine and cysteine when compared to animal protein (Olapade, 2011). Cowpea is the most economically important indigenous African legume crop (Langyinto et al., 2003). Cowpea is of vital importance to the livelihood of several millions of people in West and Central Africa.

Composite flour was described as a mixture of flours from tubers such as cassava, yam, sweet potato, legumes/protein-rich flours such as soybean, cowpea, nuts, and cereals such as maize, millet and rice with or without the inclusion of wheat flour (Seibel, 2006). Milligan et al. (1981) defined composite flour as a mixture of flours, starches and other ingredients intended to replace wheat flour totally or partially in bakery and pastry products. Shittu et al. (2007) also described

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composite flours as either binary or ternary mixtures of flours from some other crops with or without wheat flour. The application of composite flours in various food products would be economically advantageous if the imports of wheat could be reduced or even eliminated (Jisha, 2008), so that the demand for bread and other pastry products could be met using domestically grown crops instead of wheat. The preparation of acceptable biscuits from composite of wheat and cassava flour enriched with soy flour was reported (Oluwamukomi et al., 2011), but there is a paucity of information of fried chip from cassava flour enriched with cowpea flour.
The objective of this study was to evaluate the quality attributes including acceptability of fried chips prepared from blends of high quality cassava flour blended with cowpea flour.

Materials and methods

Material collection and preparation

Mature cassava roots were obtained from a farm in Ibadan, Oyo state. Red cowpea seeds were procured from Bodija market, Ibadan. All the chemicals used in this study were of analytical grade. Cassava roots were processed within 24 h after the procurement. Cassava tubers were washed in flowing water and peeled, grated with a mechanical grater and de-watered with a hydraulic press. The lump was disintegrated, dried with a flash drier and milled with a pin mill. The milled cassava flour was sieved and packed in an air-tight polythene zip-lock bags. Red cowpea seeds were soaked in clean tap water for 10 minutes, drained and manually dehulled. The dehulled cowpea was dried in a cabinet oven at 60 °C for 8 h after which it was milled into flour with a laboratory hammer mill. The samples were weighed into six equal parts of 100 g each containing 100%, 75%, 60%, 50%, 40% and 25% cassava flour with cowpea flour making it up. Fried chips were produced from each flour sample.

Chemical analysis

The chemical analyses, including proximate composition, anti-nutritional and mineral content of the samples, were carried out using standard procedures. Proximate analysis was carried out using the official methods of analysis (AOAC, 2005). Hydrogen cyanide content of the samples was determined using the alkaline picrate method as described by Onwuka (2005). Vitamin A present in the samples was determined using ultra violet visible spectrophotometer (UV-visible spectrophotometer) as described by Okwu (2004).

Determination of functional properties

Water absorption and oil absorption capacities (Sosulski et al. 1976), swelling power (Leach et al., 1959), bulk density (Okaka and Potter, 1979), dispersibility (Kulkarni et al., 1991) and foam capacity (Sathe et al*.,* 1982) were carried out using approved methods.

Determination of pasting properties

Pasting properties of the flour blends were determined using a Rapid Visco Analyzer (Newport Scientific, RVA super 3, Switzerland) as earlier described by Olapade et al. (2014).

Sensory analysis

Sensory evaluation of the cassava-chips products was carried out by twenty-five untrained panelists. The samples were presented in random order and panelists were asked to score their taste, crispness, flavour and overall acceptability on a 9-point hedonic scale where 9 represents 'extremely like' and 1 'extremely dislike'.

Statistical analysis

All determinations were done in triplicate, except when stated otherwise, and data were subjected to one way analysis of variance. Differences between means were considered to be significant at $p \leq 0.05$ using the Duncan's multiple range tests.

Results and discussion

Chemical content

Table 1 shows the chemical (proximate, anti-nutritional and vitamin) composition of the flour samples. The moisture content ranged from 9.71 to 10.30%. The highest moisture content was recorded in 100% cassava flour. The observed moisture contents were within the acceptable limit prescribed by the Standard Organization of Nigeria as reported by Sanni et al. (2005). Fat content of the flour samples ranged from 0.24 to 1.53%. The lowest fat content was recorded for sample 100% cassava flour.

Table 1. Proximate, anti-nutritional and mineral properties of cassava cowpea flour blends

Properties	Samples (Cassava: Cowpea %)					
	100:0	75:25	60:40	50:50	40:60	25:75
Moisture content (%)	10.3 ^{a} ±0.2	9.74 ^{c} ±0.20	9.71 ^{c} ±0.43	9.74 ^{c} ±0.04	9.82 ^{b} ±0.07	9.59 ^{d} ±0.10
Protein (%)	3.22 ^{d} ±0.12	7.57 ^{c} ±0.21	7.75 ^{c} ±0.45	9.23 ^{b} ±0.40	10.0 ^{ab} ±0.5	10.27 ^{a} ±0.75
Fat (%)	0.24 ^{e} ±0.05	0.40 ^{d} ±0.05	0.27 ^{e} ±0.04	0.61 ^{c} ±0.10	1.24 ^{b} ±0.05	1.53 ^{a} ±0.03
Ash (%)	0.56 ^{d} ±0.03	1.51 ^{c} ±0.02	1.57 ^{c} ±0.05	2.10 ^{b} ±0.03	2.11 ^{b} ±0.03	2.40 ^{a} ±0.02
Crude fiber (%)	1.37 ^{e} ±0.11	1.45 ^{d} ±0.03	1.53 ^{c} ±0.05	1.57 ^{bc} ±0.05	1.60 ^{b} ±0.05	1.66 ^{a} ±0.09
Amylose (%)	17.86 ^{a} ±0.30	16.39 ^{b} ±1.20	15.80 ^{c} ±0.56	15.68 ^{c} ±0.85	14.88 ^{d} ±0.54	14.65 ^{e} ±0.55
Cyanide (mg/100 g)	2.45 ^{a} ±0.13	2.21 ^{ab} ±0.21	2.18 ^{ab} ±0.06	1.82 ^{bc} ±0.04	1.62 ^{c} ±0.05	0.65 ^{d} ±0.03
Vitamin A (mg/100 g)	0.05 ^{e} ±0.01	0.07 ^{d} ±0.03	0.08 ^{cd} ±0.02	0.08 ^{c} ±0.01	0.10 ^{b} ±0.03	0.13 ^{a} ±0.02

Mean values having different superscript within the same row are significantly different (p≤0.05).

There were significant differences among the samples as fat content increased with the increase in cowpea flour content.

Cassava flour alone is very low in protein containing about 3.22%. The protein content increased with the increase in cowpea flour amount as expected. The protein content ranged from 3.22 to 10.26%. There were significant differences (p≤0.05) among the samples. The protein content observed for 100% cassava agrees with the findings of Adebowale et al. (2011). Similar result was also reported by Falade and Akingbala (2008). Crude fiber differed significantly among the samples (p≤0.05). The percentage of crude fiber increased with the increasing percentage of cowpea flour. Sample 100% cassava had the lowest percentage of crude fiber. The crude fiber content increased with increase of cowpea flour with sample 25:75 (cassava:cowpea) having the highest crude fiber content. Sample 100% cassava had the lowest ash content, while sample 75:25 cassava had the highest percentage of ash content. Ash content ranged from 0.56 to 2.40%.

The amylose content ranged from 14.7 to 17.9%, which differed significantly (p≤0.05) among the samples. The increase in the percentage of cowpea flour caused reduction in the percentage of amylose content. Amylose content is an important starch property as low amylose content leads to increased relative crystallinity of starch due to the reduced amorphous regions within the starch granule (Olapade and Adeyemo, 2014). The cyanide content was significantly different among the samples and it decreased with increasing the percentage of cowpea flour inclusion in the blends. The control sample had the highest cyanide content of 2.45 mg/100 g which was similar to the value reported by Falade and Akingbala (2008). The values of the cyanide content observed were within the range recommended by the Standard Organization of Nigeria, which is <10 mg HCN/100 g as reported by Abass et al. (1998).

The concentrations of vitamin A in the flours differed significantly (p≤0.05) among the samples. Sample 100% cassava had the lowest vitamin A content, while cowpea seeds also contained vitamin A in form of β-carotene but in higher concentration than cassava roots. Some of the vitamin A was lost during processing. Sample 100% cassava contained 0.04 mg/100 mg vitamin A and it increased with increasing concentration of cowpea flour in the blends.

Functional properties

Table 2 shows the mean values for water absorption capacity (WAC), oil absorption capacity (OAC), bulk density, swelling power, dispersibility and foam capacity of the flour samples. Sample 100% cassava had the highest WAC which differed significantly from the samples containing cowpea flour (p<0.05). The WAC ranged from 52.2 to 70.2%. Water absorption capacity is important in the development of ready to eat foods and a high absorption capacity may assure product cohesiveness (Houson and Ayenor, 2002). Carbohydrates have been reported to influence water absorption in foods (Adejuyitan et al., 2009). The observed variation in water absorption capacity among the samples may be due to difference in protein concentration and their degree of interaction with water (Butt and Batool, 2010). Oil absorption capacity of the flour samples differed significantly (p<0.05). Sample 100% cassava had the highest affinity capacity for oil. Table 2 shows the mean values for oil absorption capacities, mean values ranged from 58.5 and 70.5%. The values decreased with increasing percentage of cowpea flours. Similar values were reported by (Adebowale et al., 2011; Ikegwu et al., 2009). Oil absorption capacity is important as it indicates flour suitability in facilitating enhancement in flavour, mouth feel of foods, improvement of palatability and extension of shelf life especially in bakery products (Aremu et al., 2007; Appiah et al., 2011).

The increase in the percentage of cowpea flour decreased the swelling power of the flour samples. There were significant differences (p<0.05) among the samples. Swelling power of 100% cassava flour was 9.9%.

Table 2. Functional properties of cassava-cowpea flour

Samples Cassava:cowpea	WAC (%)	OAC (%)	B.D (g/ml)	S.P (%)	DISP (%)	F.C (%)
100:0	70.2 ^{a} ±2.5	70.5 ^{a} ±3.0	0.83 ^{a} ±0.02	9.9 ^{a} ±1.1	88 ^{a} ±6	2.4 ^{a} ±0.2
75:25	63.5 ^{ab} ±1.8	62.5 ^{bc}±3.3	0.83 ^{a} ±0.01	7.5 ^{bc} ±0.8	88 ^{a} ±2	3.2 ^{b} ±0.3
60:40	63.7 ^{ab} ±2.0	66.5 ^{ab} ±3.0	0.70 ^{b} ±0.01	8.9 ^{ab} ±0.3	86 ^{a} ±2	4.8 ^{c} ±0.1
50:50	61.4 ^{bc} ±2.5	59.0 ^{c} ±2.1	0.83 ^{a} ±0.05	8.2 ^{bc} ±1.1	86 ^{a} ±2	5.2 ^{d} ±0.4
40:60	52.2 ^{c} ±1.9	62.0 ^{bc} ±2.6	0.75 ^{b} ±0.07	6.8 ^{c} ±0.9	87 ^{a} ±3	5.6 ^{e} ±0.5
25:75	60.3 ^{bc} ±3.0	58.5 ^{c} ±1.8	0.75 ^{b} ±0.05	7.8 ^{b} ±0.9	86 ^{a} ±2	6.8^{f}±0.6

Mean values having different superscript within the same column are significantly different ($p \le 0.05$). WAC-water absorption capacity, OAC- oil absorption capacity, B.D- bulk density, S.P- swelling power, DISP- dispersibility, F.C- foaming capacity.

This agrees with the findings of Oladunmoye et al. (2014). Bulk density values were not significantly different among 100% cassava, 75:25 cassava and cowpea, and 50:50 cassava:cowpea. However, the three samples were significantly different ($p<0.05$) from 40:60 cassava:cowpea, and 25:75, cassava:cowpea flours. The variation in bulk density could be a result of variation in starch content. Iwe and Onadipe (2001) reported that starch content increases bulk density. Foam capacity of the flour blends increased with increasing percentage of cowpea flour. There were significant differences ($p<0.05$) in the foam capacity of the samples. Sample 100% cassava had the lowest foam capacity. Similar results were obtained by Adebowale et al. (2011). Dispersibility of the flour blends were 86-88% and it did not differ significantly ($p>0.05$) from one another. The results observed were similar to the values reported by Alawode et al. (2017) for blends of sweet potato-sorghum-soybean. Dispersibility is the ability of flour to wet without formation of lumps, with simultaneous integration of agglomerates and it indicates the reconstitution ability of flour (Otegbayo et al., 2013).

Pasting properties

Table 3 shows the peak viscosity, trough, breakdown, final viscosity, set back, peak time and peak temperature of all the samples. The peak viscosity is the maximum viscosity attainable during the heating cycle and it ranged from 188.42 to 428.38 RVU for the samples. Peak viscosity decreased with increasing percentage of cowpea flour and differed significantly ($p \le 0.05$) among the samples. The trough value for 100% cassava was significantly different from other samples that containing cowpea flour, whereas there was no significant difference among all samples containing cowpea flour. Breakdown viscosity index ranged from 57.92 to 288.00 RVU. The 100% cassava had the highest breakdown viscosity and the values reduced with increasing percentage of cowpea flour. The breakdown viscosity differed significantly ($p \le 0.05$) among the samples. Adebowale et al. (2011) reported that the higher the breakdown viscosity the lower the ability of the sample to withstand heating and shear stress during cooking.
Final viscosity of the samples ranged from 179.50 to 204.42 RVU. There were significant differences ($p \le 0.05$) among the samples. The setback viscosity ranged from 53.17 to 69.75 RVU. The 100% cassava had a setback value of 64.05 RVU. The peak time increased steadily with the increase in percentage of cowpea flour. The peak time for 100% cassava was 4 min, which was similar to the value reported by Falade and Akingbala (2008). The pasting temperature increased with the increase in percentage of cowpea flour and differed significantly among the samples. The pasting temperature ranged from 74 to 91 ^{o}C with 100% cassava flour having 74.45 ^{o}C.

Table 3. Pasting properties of cassava-cowpea flour sample

Properties	Samples (Cassava:Cowpea%)					
	100:0	**75:25**	**60:40**	**50:50**	**40:60**	**25:75**
Peak viscosity (RVU)	428.4^{a}±12.5	282.0^{b}±21.1	252.7^{c}±21.0	227.7^{d}±23.4	210.5^{e}±11.1	188.4^{f}±12.0
Trough (RVU)	124.3^{c}±11.4	126.5^{bc}±5.5	125.5^{bc}±5.0	128.8^{bc}±8.7	131^{ab}±6.3	140.4^{a}±4.8
Breakdown (RVU)	288^{a}±21.5	157.8^{b}±31.4	126.3^{c}±7.8	101.5^{d}±3.2	81.7^{e}±4.0	57.9^{f}±4.6
Final viscosity (RVU)	204.4^{a}±18.6	179.5^{d}±18.0	179.6^{d}±6.0	180.3^{d}±4.5	187.1^{c}±5.4	200.3^{b}±12.2
Set back (RVU)	64.1^{b}±3.6	55.3^{cd}±4.6	53.2^{d}±2.2	54.7^{d}±3.0	58.3^{c}±2.0	69.8^{a}±3.0
Peak time (min)	4.0^{e}±0.7	4.77^{d}±1.0	4.93^{c}±1.1	5.1^{b}±1.0	5.2^{a}±0.9	5.2^{a}±1.2
Pasting temp (°C)	74.4^{e}±3.2	74.4^{e}±5.0	75.1^{d}±3.0	76.3^{c}±3.2	91.9^{a}±5.1	89.5^{b}±4.0

Mean values having different superscript within the same row are significantly different ($p \le 0.05$).

Table 4. Mean score for sensory acceptability of cassava-cowpea fried chips

Samples Cassava :cowpea %	Taste	Flavor	Crispness	Overall acceptability
100:0	$5.1^{c} \pm 1.0$	$6.50^{bc} \pm 0.5$	$5.4^{c} \pm 0.6$	$5.0^{c} \pm 0.5$
75:25	$4.5^{c} \pm 1.2$	$6.1^{c} \pm 0.4$	$6.5^{b} \pm 0.7$	$7.5^{bc} \pm 0.7$
60:40	$6.3^{b} \pm 1.2$	$6.7^{bc} \pm 0.5$	$6.7^{b} \pm 0.6$	$6.6^{b} \pm 0.6$
50:50	$7.7^{a} \pm 0.5$	$7.7^{a} \pm 0.5$	$7.8^{a} \pm 0.5$	$7.8^{a} \pm 0.7$
40:60	$7.0^{a} \pm 1.1^{a}$	$7.1^{ab} \pm 0.7$	$7.4^{a} \pm 0.5$	$7.1^{ab} \pm 0.3$
25:75	6.7 ± 1.0^{ab}	$6.5^{bc} \pm 0.5$	$6.3.6^{b} \pm 0.5$	$6.5^{b} \pm 0.6$

Mean values having different superscript within the same column are significantly different ($P \leq 0.05$).

Sensory attributes

The mean sensory values are presented in Table 4. There were significant differences among samples for taste, flavour, crispness and overall acceptability. The 50:50 (cassava:cowpea) had the highest score for all the parameters followed by sample 40:60 (cassava:cowpea). The 100% cassava had the lowest score for taste (5.1), while 50:50 had the highest score. Taste scores increased with the increase in percentage of cowpea flour. However, sample 50:50 had the peak value for taste as it decreased with continuous increase in cowpea flour. Most judges neither liked nor disliked sample 100% cassava but liked 50:50 very much. There were significant differences ($p \leq 0.05$) among the samples for flavor. Samples 50:50 and 40:60 had the highest flavour scores. There was no significant difference among samples 100%, 60:40 and 25:75 as they were all liked slightly by the judges. Sample (75:25) was the least scored sample.

Crispiness decreased with increasing cassava flour concentration until sample 50:50, when further decrease in cassava flour led to a decrease in crispiness score. The 100% was the least scored for crispiness, while samples 50:50 and 40:60 were scored the highest. There were significant differences ($p \leq 0.05$) among the samples. The 50:50 had the highest overall acceptability score of all the other samples, while 100% cassava chip and 75:25 (cassava:cowpea) chips were the least scored having mean scores of 5.0 and 5.4, respectively. There was no significant difference between samples 60:40 and 25:75 samples as they were both liked slightly.

Conclusions

This study showed that high quality cassava flour can be effectively supplemented with cowpea flour to improve its protein content and crispness for use in unleavened pastry production. This study also showed that incorporation of cowpea flour reduced the cyanide content of cassava flour thereby making it safer for consumption. Further increase in the ash and fiber content of the flours showed that the nutritional properties of high quality cassava flour can be effectively improved by the addition of cowpea flour. The pasting and functional properties obtained indicate that addition of cowpea flour to cassava flour up to 60% has a lot of potentials in the baking industry.

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