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Effect of Sorghum Leaf Sheath and Extract on Chemical and Sensory Properties of Boiled Cowpea

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Abstract

The study assessed effect of sorghum leaf sheath and extract on the chemical and sensory properties of boiled cowpea. Cowpea seeds, sorghum leaf sheath, salt, pepper and palm oil were purchased from Rumuokoro Market in Port-Harcourt, Rivers State. Materials were sorted, weighed and prepared. Samples were produced using standard methods.Samples were assessed for proximate, energy, mineral, phytochemical content and sensory properties using standard methods of analysis. Data were analyzed using means and standard deviation, analysis of variance and Duncan Multiple Range test. Results show, among others, moisture content was highest (58.27%) in sample boiled with sorghum leaf sheath while ash content did not differ significantly (p>0.05) among the samples and ranged between 2.01% and 2.92%. Cowpea boiled with palm oil had the highest fat (10.53%), energy (237.93 kcal) and lowest protein content (8.84%). Crude fibre differed significantly among the samples and was highest in cowpea boiled with sorghum leaf sheath (1.85%). Carbohydrate varied significantly with cowpea boiled with sorghum leaf sheath extract having the highest (31.13%). Calcium (11.94mg) and zinc (1.74mg) was highest in cowpea boiled with sorghum leaf sheath extract while phosphorus was highest (11.41mg) in cowpea boiled with palm oil. Cowpea boiled with palm oil had the highest values for carotenoid (3.34mg) and alkaloid (7.95%) when compared with other samples. Saponin (8.42%) was highest in cowpea containing sorghum leaf sheath. Boiled cowpea samples varied significantly in their colour, flavour, taste and overall acceptability while texture did not vary significantly. Cowpea boiled with palm oil was the most preferred having higher mean scores for all the sensory attributes. Cowpea boiled with sorghum leaf sheath compared favourably with the one containing palm oil in all sensory attributes.

Keywords: Cowpea, Colour, Chemical, Sensory, Sorghum leaf sheath, Extract, Properties.

Introduction

Sensory evaluation is a scientific means of assessing consumers' acceptability of food products by analyzing and interpreting the reactions of consumers in relation to the characteristics of food products as perceived by the sense organs (Mbela, *et al*, 2018). Some of the sensory characteristics of foods include colour, appearance, taste, aroma and texture. Colour is the most important sensory attribute of foods that affects consumers' preference and acceptability of foods. It is usually the first sensation perceived by the consumer and is used to judge the quality of the food and influences the decision to accept or reject the food. Beleya, Allen and Eke-Ejiofor (2023) noted that sensory appeal has a greater influence on consumers' choice of foods than the nutrient composition. Food manufacturers use different food colours to improve the appearance, increase the colour intensity and obtain a more stable or uniform colour (Farzianpour *et al*., 2013).

Food colour is any pigment which impart colour when added to food (Novais *et al*., 2022).Dey and Nagabadu, (2022) defined food colour as any dye or other substances that produces colour when added to food, drink or beverage. Food colour could be natural or synthetic. Several natural and synthetic food colours are used in the food industry and for home cooking. Synthetic food colours are chemicals obtained from coal tar derivatives, most of which contain dyes from the azo group (Zahra,*et al*., 2015). Synthetic food colours are a major source of food intoxication (Saleem, Umar and Khan, 2013). Some synthetic food colours however, do not pose appreciable risk to the health of the consumer when used within the permissible limits (Mittal, 2020). The use of non-permitted and indiscriminate use of permitted synthetic food colours results in severe health problems such as low haemoglobin concentration, allergic reactions, mutations, cancers, irritability, sleeping disturbances, asthma, various effects on the liver, kidney and intestine and hyperactive effects in children (Bachalla, 2016; Dey and Nagababu, 2022).

Consumers' awareness of the adverse health effects of synthetic food colours has increased the use of natural food colours (Varghese and Ramamoorthy, 2023). Natural food colours can be obtained from plants, insects, algae and fungi (Novais *et al.,* 2022). They are ecofriendly, biodegradable, have no disposal problems and their mode of production involve minimum possibility of chemical reactions (Joshi, *et al*., 2011; Abdeldaiem, 2013). Natural food colours are as effective as synthetic colours; they are safer, provide additional health benefits and organoleptic characteristics (Novais *et al.,* 2022).

One of the natural food colours used traditionally in Nigeria and parts of West Africa is the dye from sorghum leaf sheath. The leaf sheath is the part of the leaf that wraps around the stem. Sorghum leaf sheaths contain bioactive compounds with antioxidant properties such as anthocyanin, phenols and flavonoids (Tugli *et al*., 2019). The colouring ability of sorghum leaf sheath is due to the presence of anthocyanins. Sorghum leaf sheath is used as a food colour either by adding the sheaths to food during cooking or by using the extract as the cooking liquid. Sorghum leaf sheath and its extract are used to add or enhance the colour of foods such as cereals, legumes, fermented cereal-based porridges such as pap and fruit drinks. A popular Ghanaian dish known as 'waakye' is usually prepared with boiled beans and rice with sorghum leaf sheath as a colouring agent (Tugli *et al*., 2019). The leaf sheath is also used to add colour to boiled cowpea (doungouri) in Benin republic and other parts of West Africa (Akogou,*et al*., 2018).

Cowpea (*Vigna unguiculata*) is a legume which belongs to the family *Fabaceae*. It is amongst the most consumed legumes and one of the cheapest sources of plant protein in the diet of most Nigerians (Barber, *et al*., 2010). It contains two or more times more protein than cereals and root/tuber crops (Goncalves, *et al*., 2016). Cowpea is rich in phytochemicals, minerals and other nutrients that promote health. Studies have been carried out on nutruient composition of cowpea(Omenna, *et al*., 2016).

Cowpea can be processed into different forms for consumption. It is usually boiled alone or mixed with cereals and eaten with stew or sauce or made into pottage and consumed alone or with cereal gruel such as pap. They can also be made into products such *"akara"* and *moi-moi*. Cowpea pottage is usually prepared by adding palm oil to boiled cowpea. The addition of palm oil enhances the colour and sensory appeal and could add other nutrients to the dish.

Palm oil is one of the most widely used edible oils by households.It contains 50% saturated fatty acid, 40% monounsaturated and 10% polyunsaturated fatty acid with palmitic acid being the predominant saturated fatty acid (Tan *et al*., 2021).It is also rich in phytonutrients such as carotenoids, tocopherols, sterols, phospholipids and polyphenols (May and Nesaretnam, 2014). The colouring ability of palm oil is due to the high amount of carotenoid which is a precursor of vitamin A and also responsible for its orange-red colour. The high content of saturated fatty acids in palm oil could be a risk factor for the development of cardiovascular diseases. The saturated fats in palm oil have the same effect on cholesterol (Low density lipoproteins)as that of animal fat (Sun *et al*, 2015). It is appropriate to limit the use of palm oil when preparing meals for individuals requiring low fat diets such as the obese, diabetic, cardiovascular diseases and hypercholesteremia patients. Natural food colours such as sorghum leaf sheath and its extracts add colour without increasing the fat content of the food. Thus, the study aimed at assessing the effect of sorghum leaf sheath and extract on the chemical and sensory properties of boiled cowpea.

Purpose of the study

The broad purpose of the study was to assess effect of sorghum leaf sheath and its extract on the chemical and sensory properties of boiled cowpea. Specifically, the study determined the effect sorghum leaf sheath and its extract on:

1. proximate (moisture, ash, protein crude fibre, carbohydrate) and energy composition of boiled cowpea.
2. mineral (calcium, magnesium, zinc, phosphorus) composition of boiled cowpea.
3. phytochemical (carotenoid, alkaloid, saponin) composition of boiled cowpea.
4. sensory properties (colour, flavour, taste, texture, overall acceptability) of boiled cowpea.

Material and Methods

Design of the Study: Experimental research design was used for the study.

Procurement of Materials: Cowpea (*Vigna unguiculata*) seeds, sorghum leaf sheaths, pepper and salt were purchased from Rumuokoro Market in Port-Harcourt, Rivers State. The chemicals used for analysis wereof analytical grade and were obtained from the Laboratory of the Department of Food Science and Technology, Rivers State University, Port-Harcourt Rivers State.

Preparation of the Samples: Cowpea seedswere sorted, weighed, soaked the in 500ml of boiled water for 10 min and washed.The method described by Omenna *et al*., (2016) with slight modification was used to prepare the four different samples, follows:

(1) Plain boiled cowpea (Negative control) (PBC)
(2) Cowpea boiled with sorghum leaf sheath (SLC)
(3) Cowpea boiled with sorghum leaf sheath extract (SEC)
(4) Cowpea boiled with plain oil (Positive control) (POC)

Similar recipe and preparation method were applied to each of the four samples, except the four sample treatments as follows:

Ingredients	**Quantity**
Cowpea seeds	200g
Dried pepper (ground)	0.6g
Salt	0.6g
Water	1500ml

Preparation Method

1. Put water, salt and pepper into a saucepan.
2. Added the cowpea seeds and placed over medium heat on a gas cooker.
3. Boiled for 70 minutes and removed from the heat source.

Chemical Analysis: The samples were packed in airtight plastic containers and stored in the refrigerator prior to analysis. All analysis was done in duplicate.

Determination of Proximate Composition: The proximate compositions of all the boiled cowpea samples were determined according to AOAC (2012). Appropriate formula was used for calculation of contents:

Moisture: Five grams (5g) of each sample was weighed into a can of known weight and dried in an oven at 105^{o}C for 16 hours. The can and content were cooled in a dessicator and weighed.

Ash: Five grams(5g) of the sample was weighed into a crucible and put in the muffle furnace at 550^{o}C. When ashed, it was cooled in a dessicator, weighed and the percentage ash was calculated.

Fat: The sample (1 g) was wrapped with a filter paper, put in an extraction flask with300 ml of hexane, mounted on the soxhlet apparatus and boiled for 4 hours. The extracted sample was removed, oven dried at 100^{o}C for 30 min, cooled and weighed.

Protein: Micro Kjeldhal method was used to determine total nitrogen by boiling 0.5g of the sample in 10mls concentrated H_2SO_4using selenium ascatalyst. The digest was mixed with 10ml of 45% NaOH, 10ml of 4% boric acid and 3 drops of mixed indicator (bromocresol green/methyl red) added and 50ml of the distillate was titrated against 0.02N H_2SO_4solution until a deep red end point was obtained. The protein content was calculated by multiplying the value for total nitrogen by 6.25 (protein-nitrogen conversion factor).

***Crude Fibre*:**Defatted sample (1g) was boiled with 150ml of 1.25% NaOH for 30 minutes, filtered, the residue washed severally with hot distilled water, drained, dried at 105ºC to a constant weight and ashed in a muffle furnace at 550ºC for 6 hours, cooled, weighed. The loss in weight was used to estimate percentage crude fibre.

***Carbohydrate and Energy Content*:** Carbohydrate was calculated by difference by adding the values for moisture, ash, fat, protein and crude fibre and subtracting it from 100. The method described by Eke-Ejiofor and Beleya (2018) was used to calculates energy content by summing the product of multiplying the Atwater factors (4:9:4) for protein, fat and carbohydrate by their percentage compositions.

***Determination of PhytochemicalComposition of the Samples*:** The following contents were determined:

***Carotenoid*:** The spectrophotometric method described by Onwuka (2018) was used. Five grams (5g) of each sample was extracted with acetone and petroleum ether (1:1 v/v) until a colourless residue was obtained. The absorbance was read at 470 nm using beta-carotene for the standard curve.

***Alkaloid*:** The alkaline precipitation method was used (Nwosu (2013). A solution was made with 5 g of the sample, 10% acetic acid and ethanol and kept at room temperature for 4 hours. It was filtered and the filtrate concentrated by evaporation and treated with conc. NH_3, filtered and the precipitate dried at 60ºC for 2hours, weighed and the alkaloid content determined.

***Saponin*:** This was determined by the double extraction gravimetric method as described by Nwosu (2013). One gram (1) of each sample was extracted with 20% aqueous ethanol for 12 hours, re-extracted for 30 minutes, evaporated and separated. The aqueous layer was re-extracted, the pH reduced with NaOH, re-extracted with normal butanol, dried at 60°C for 30 minutes and the percentage saponin calculated.

***Determination of Mineral Composition*:** The method described by Eke-Ejiofor, Beleya and Allen (2021) was used. The samples were digested with a mixture of perchloric (HClO4), nitric (HNO3) and sulfuric (H2SO4) acids. The digest was used for the estimation of the mineral content of the samples based on the absorbance at wavelengths of 422.6 nm (calcium), 202.6 nm (magnesium), 766.5 nm (zinc) and 625 nm (phosphorus). The concentration of minerals in the boiled cowpea samples were determined using an Atomic Absorption Spectrophotometer (AAS) (model 5100 PCAAS, Perkin Elmer, USA).

***Sensory Evaluation of Boiled Cowpea*:** The procedure described by Iwe (2010) was modified and used for the sensory evaluation.

***Panel of Judges*:** Twenty member semi trained panel made up of Staff and students of the Department of Home Science and Management, Rivers State University, Port Harcourt evaluated the samples. Participants were chosen based on their willingness and familiarity with the product.

***Instrument for Data Collection*:** instrument used was a scoring sheet based on 9-point hedonic scale of like extremely (9 points), like very much (8), like moderately (7 points), like slightly (6 points), neither like nor dislike (5 points), dislike slightly (4 points), dislike moderately (3 points), dislike very much (2 points), and dislike extremely (1 point), (Ihekoronye & Ngoddy, 1985).

Data Collection Procedure: The prepared gruels were coded as samples 1, 2, 3, and the control. Samples were randomly served to the panelists. They were to taste, score each sample, and rinse their mouths before proceeding to the next sample. The tasting was carried out in a well-ventilated and lighted place (Home Economics Food Laboratory). The sensory attributes tested and scored were texture, appearance, (colour), aroma, mouth feel and general acceptability.

Data Analysis: Data were analyzed using means and standard deviation. Analysis of variance (ANOVA) was used to test for differences among the means while Duncan Multiple Range Test was used to separate the means for significant differences at P< 0.05. The statistical package for social sciences (SPSS) version 21.0 was used for data analysis.

Results

Table 1: Proximate and Energy Composition of Boiled Cowpea (Wet Weight Basis)

Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Crude fibre (%)	Carbohydrate (%)	Energy (kcal)
PBC	55.06^{b}±0.00	2.24^{a}±0.00	1.28^{b}±0.00	10.21^{a}±0.91	1.33^{c}±0.16	29.88^{b}±0.75	171.88^{b}±1.65
SLC	58.27^{a}±0.33	2.92^{a}±0.00	1.12^{b}±0.09	10.16^{a}±0.01	1.85^{a}±0.00	25.68^{c}±0.43	153.44^{b}±3.22
SEC	53.57^{c}±0.00	2.54^{b}±0.00	1.30^{b}±0.10	9.64^{a}±0.33	1.82^{a}±0.00	31.13^{a}±0.22	174.78^{b}±3.33
POC	50.13^{d}±0.01	2.01^{a}±0.74	10.53^{a}±1.37	8.84^{ab}±0.38	1.54^{b}±0.03	26.95^{c}±0.97	237.93^{a}±2.97

Means with the same superscript along the same column are not significantly different (p<0.05)Key: PBC = Plain boiled cowpea, SLC = Cowpea boiled with sorghum leaf sheath, SEC = Cowpea boiled with sorghum leaf sheath extract, POC = Boiled cowpea with palm oil

Table 1 revealed that the moisture and ash contents ranged from 50.13% and 2.01% in sample boiled with palm oil to 58.27% and 2.94% in sample boiled with sorghum leaf sheath respectively. Fat content increased from 1.12% in sample boiled with sorghum leaf sheath 10.56% in sample boiled with palm oil. Protein content was highest (10.21%) in the plain boiled sample while sample boiled with palm oil had the least (8.84%). Crude fibre increased from 1.33% in the plain boiled sample to 1.85% in sample boiled with sorghum leaf sheath. Sample boiled with sorghum leaf sheath had the least carbohydrate (25.68%) and energy (153.44 kcal) values. Cowpea boiled with sorghum leaf sheath extract and the one boiled with palm oil had the highest carbohydrate (31.13%) and energy (237.93 kcal) values respectively.

Table 2: Mineral Composition of Boiled Cowpea (mg/100g)

Samples	Calcium	Magnesium	Zinc	Phosphorus
PBC	9.45^{c}±0.01	1.64^{a}±0.02	0.91^{b}±0.09	9.42^{c}±0.02
SLC	11.10^{b}±0.01	1.59^{a} ±0.00	1.42^{a}±0.15	8.45^{d}±0.05
SEC	11.94^{a}±0.07	1.68^{a}±0.15	1.74^{a}±0.08	10.36^{b}±0.00
POC	6.15^{d}±0.11	1.61^{a}±0.11	0.93^{b}±0.12	11.41^{a}±0.29

Means with different superscript on the same column are significantly different (P< 0.05).Key: PBC = Plain boiled cowpea, SLC = Cowpea boiled with sorghum leaf sheath, SEC = Cowpea boiled with sorghum leaf sheath extract, POC = Boiled cowpea with palm oil

Table 2 shows the mineral composition of the boiled cowpea. The calcium content ranged between6.15mg in sample boiled with palm oil and 11.94mg in sample boiled with sorghum leaf sheath extract. The magnesium content of the samples did not vary significantly and was between 1.59mg and 1.68mg. Zinc increased from 0.91 mg in the plain boiled sample to 1.74 mg in sample boiled with sorghum leaf sheath extract while phosphorus ranged from 8.45 mg in sample boiled with sorghum leaf sheath to 11.36mg in sample boiled with palm oil.

Table 3: Phytochemical Composition of Boiled Cowpea

Samples	**Carotenoid (mg/100g)**	**Alkaloid (mg/100g)**	**Saponin (%)**
PBC	1.17^{b}±0.03	3.07^{b}±0.25	7.29^{a}±0.11
SLC	1.55^{b}±0.13	2.23^{c}±0.01	8.42^{a}±0.07
SEC	1.75^{b}±0.33	2.16^{c}±0.19	7.24^{a}±0.83
POC	3.34^{a}±2.25	7.95^{a}±0.22	5.10^{b}±0.32

Means with different superscript on the same column are significantly different (P< 0.05). Key: PBC = Plain boiled cowpea, SLC = Cowpea boiled with sorghum leaf sheath, SEC = Cowpea boiled with sorghum leaf sheath extract, POC = Boiled cowpea with palm oil

Table 3 shows the phytochemical composition of the cooked cowpea. The carotenoid content ranged from 1.17mg in plain boiled sample to 3.34mg in sample boiled with palm oil. Sample boiled with sorghum leaf sheath extract had the least (2.16ng) content of alkaloid while sample boiled with palm oil (7.95mg) had the highest. Saponin content varied between 5.10% and 8.42% with sample boiled with palm oil having the least and sample boiled with sorghum leaf sheath having the highest.

Table 4: Mean Sensory Scores of Boiled Cowpea

Samples	Colour	Flavour	Taste	Texture	Overall Acceptability
PBC	5.09^{c}±2.09	5.55^{c}±1.89	6.45^{ab}±1.65	6.81^{a}±1.68	6.05^{b}±1.21
SLC	6.64^{b}±1.62	7.00^{ab}±1.11	7.00^{ab}±1.95	6.27^{a}±1.96	6.73^{ab}±1.22

Table 4 continued

SEC	$5.64^{c}\pm1.56$	$6.27^{bc}\pm1.45$	$6.00^{c}\pm1.51$	$6.36^{a}\pm1.70$	$6.07^{b}\pm1.29$
POC	$7.77^{a}\pm1.15$	$7.36^{a}\pm1.29$	$7.32^{a}\pm1.43$	$6.86^{a}\pm1.39$	$7.32^{a}\pm1.00$

Means with different superscript on the same column are significantly different ($P< 0.05$).
Key: PBC = Plain boiled cowpea, SLC = Cowpea boiled with sorghum leaf sheath, SEC = Cowpea boiled with sorghum leaf sheath extract, POC = Boiled cowpea with palm oil

Table 4 shows the mean sensory scores for boiled cowpea. Colour ranged from 5.09 in plain boiled sample to 7.77 in sample boiled with palm oil. The likeness for flavour of the cowpea samples increased from 5.55 in plain boiled sample to 7.36 in sample boiled with palm oil. Sample boiled with sorghum leaf sheath extract had the least score (6.00) for taste while sample boiled with palm oil had the highest (7.32). The texture of the samples ranged between 6.27 and 6.86. Sample boiled with palm oil was the most liked with an overall acceptability score of 7.32 while the least liked was the plain boiled sample with a score of 6.05.

Discussion of Findings

The result of the chemical composition of the boiled cowpea revealed that moisture content of the samples differed significantly with cowpea boiled with palm oil having the least moisture content. This could be due to the higher fat content of the sample which may have reduced the level of water activity. The lower moisture content of the cowpea with palm oil implies it would store longer than the others samples. There was no significant difference in the ash content of the cooked cowpea. Cowpea boiled with sorghum leaf sheath had slightly higher (2.92%) content of ash. The ash content of the samples were lower than 3.57% reported by Omenna *et al* (2016) for ash content of boiled cowpea. The fat content of the boiled cowpea varied significantly with the sample with palm oil having the highest fat content. This is expected as palm oil is a rich source of fat. Similar finding was reported by Ndife, Nwaubani, and Aniekpeno (2019) for garri incorporated with palm oil. The lower fat content (1.12%) of the sample boiled with sorghum leaf sheath is beneficial as it will be less susceptible to oxidative rancidity. The protein content of the samples boiled with sorghum leaf sheath and extract did not vary significantly with that of the plain boiled cowpea. The values for protein were lower than 17.79% reported for protein content of boiled cowpea by Omenna *et al* (2016) which could be attributed to varietal differences. The fibre content of the boiled cowpea was highest in cowpea boiled with sorghum leaf sheath and was not significantly different from cowpea boiled with the extract. The increase in fibre could be due to the sorghum leaf sheath and its extract as some particles of the leaf sheath may be present in the extract and in the sample boiled with the leaf sheath thus, contributing to higher fibre content. The fibre content of the boiled cowpea samples were higher than 1.00% reported for plain boiled brown-eye cowpea by Abdulazeez *et al* (2019). Carbohydrate varied significantly among the samples which could be due to the amount of other nutrients present in the samples since carbohydrate was calculated by difference. Omenna *et al* (2016) reported variations in the carbohydrate content of differently processed cowpea. Their values (57.21-59.74%) were higher than what was observed in the present study. The energy content was significantly higher in cowpea boiled with palm oil. This is due to the higher fat content of the sample as fat provides more energy compared to protein and carbohydrate.

The mineral composition of the boiled cowpea showed that calcium varied significantly ($p<0.05$) among the samples. Cowpea boiled with sorghum leaf sheath extract had the highest calcium content (11.94 mg). Affrifah, Phillips and Saalia (2022) reported higher calcium content (24 mg) in boiled cowpea. The magnesium content of the boiled cowpea were statistically similar which implies that the different methods had no significant effect on the magnesium content of the boiled cowpea. Zinc increased from 0.91 in plain boiled cowpea to 1.74 mg in cowpea boiled with sorghum leaf sheath extract. Sorghum leaf sheath is high in zinc and may have contributed to the higher content of zinc in the samples with the sorghum leaf sheath and the extract.Adetuyi, Akpambang, Oyetayo and Adetuyi (2007) reported 7.15mg as zinc content of sorghum leaf sheath flour. Oluwalana and Adedeji (2013) reported 2.50mg of zinc in sorghum leaf sheath beverage. The phosphorus content of the boiled cowpea samples were higher than the values (4.63 -5.92 mg) reported for different cowpea genotypes by Gerrano *et al*., (2019).

The phytochemical composition of the boiled cowpea showed that carotenoid content increased significantly (3.34%) in cowpea boiled with palm oil. Zhu *et al*., (2015) noted that palm oil is a rich source of carotenoids. Alkaloid was significantly higher (7.95mg) in cowpea boiled with palm oil but reduced in cowpea boiled with sorghum leaf sheath and that of the extract. High intake of alkaloids above its lethal dose of 20mg could be toxic to humans (Inuwa, Aina, Aimola and Amao, 2011). Saponin content was significantly lower in cowpea boiled with palm oil. Saponins are hydrophilic and have high foaming properties (Góral and Wojceichowski, 2020). The addition of palm oil may have reduced its foaming ability thus, resulting in the reduction in saponin content.

The result of the sensory attributes of the boiled cowpea samples showed that the mean values varied significantly among the samples in terms of colour, flavour, taste and overall acceptability while the texture did not differ significantly. Adegoke *et al*., (2019) reported that different cooking conditions had significant effect on all the sensory attributes of pressure coked cowpea. Cowpea boiled with palm oil had the highest mean rating for all the attributes assessed and overall acceptability. This could be due to consumers' familiarity with the sample. Also, the high fat content of the cooked cowpea with palm oil may have also contributed to the higher scores for flavour and taste of the sample as fat is known to contribute to the flavour and taste of foods. Fats are precursors of flavour compounds thus, they add flavour to foods and influence the order in which flavour components are released when food is eaten (Shahidi and Hossain, 2022; Rios *et al.,* 2014). There was no significant difference in the texture of the cowpea samples. The findings is at variance with that of Adegoke *et al*., (2019) who reported significant difference in the texture of pressure cooked cowpea. However, cowpea cooked with sorghum leaf sheath compared favourably with the sample with palm oil for all sensory attributes and overall acceptability.

Conclusion

The findings of the study revealed that sorghum leaf sheath and the extract had no significant effect on the ash, fat, protein, carotenoid, saponin and magnesium contents of the boiled cowpea. Crude fibre, calcium and zinc were higher in cowpea boiled with sorghum leaf sheath and its extract. Palm oil significantly increased the fat, carotenoid and phosphorus contents of the boiled cowpea samples. Cowpea boiled with palm oil was the most acceptable to the consumers in all sensory attributes. However, cowpea boiled with sorghum leaf sheath compared favourably with that of palm oil in all sensory attributes. Besides adding colour, sorghum leaf sheath and its extract enhanced the mineral content and sensory attributes of the boiled cowpea samples without increasing the fat content.

Recommendations

Based on the findings, the following recommendations are made:

1. Sorghum leaf sheath and its extract should be used as food colour instead of palm oil when preparing foods for people requiring low fat diets.
2. Home makers should be encouraged to use sorghum leaf sheath and its extract as food colour as it contributes to the mineral content of foods.
3. The use sorghum leaf sheath and its extract in place of synthetic food colours in the food industry should be encouraged.
4. Further studies should be carried out to assess the effect of sorghum leaf sheath and its extract in beverage production.

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