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Proximate composition and sensory acceptability of cowpea-based pudding produced from cowpea cultivated using different weed control methods

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Abstract. This study evaluates the effect of different weed control methods on the proximate composition and sensory properties of cowpea-based pudding produced from cowpea flour. Cowpea seeds of Ife Brown variety with three different treatments [(supplementary hoe weeding at 6 weeks after sowing, two hoe weeding at 3 and 6 weeks after sowing, and three hoe weeding at 3, 6, and 9 weeks after sowing (WAS)] were processed into flour samples and analysed for physicochemical properties using standard methods. The puddings were prepared from cowpea flour and were subjected to proximate composition, colour properties as well as sensory qualities using standard methods. The pH, total titratable acidity, water absorption capacity and amylose of cowpea flour were 4.85–5.10, 0.02%–0.05%, 276.00%–287.09%, and 22.04%–24.60% respectively. The ranges of values for moisture content, crude fat, total ash, crude fibre, crude protein, and total carbohydrate of cowpea based pudding were 74.26%–76.15%, 0.63%–0.71%, 0.75%–0.94%, 0.66%–0.75%, 16.70%–17.83%, and 5.11%–5.55% respectively. The colour properties of cowpea-based pudding were significantly affected ($p < 0.05$) by each treatment. However, cowpea-based pudding prepared from treatment of supplementary hoe weeding at 6 weeks after sowing and three hoe weeding at 3, 6, and 9 weeks after were preferred most by the panelist.

Keywords and phrases: cowpea, cowpea-based pudding, weed control

1. Introduction

Cowpea, also called black-eyed pea or southern pea, and botanically named Vigna unguiculate, is an annual crop belonging to the pea family and grown for its edible legumes (*Encyclopedia Britannica*, 2022). Cowpea is native to West Africa and cultivated around the world. They are crops that have compound leaves with three leaflets with climbing or trailing vines. The flowers of the plant usually grow in pairs or threes at the tip of long stalks and are usually of white, purple, or pale yellow colour. Depending on the cultivar type, their pods are usually long with cylindrical shape growing up to 20-30 cm. Cowpeas can grow in a wide range of soils and can develop well under water stress (*Dugje et al.*, 2009). It is a staple food that contributes to human nutrition with large amounts of proteins, carbohydrates, dietary fibres, vitamin of the B-complex, essential minerals, and a small quantity of lipids, and it has lower levels of anti-nutritional factors (*Nassourou et al.*, 2016; *Mtolo et al.*, 2017). Cowpea possesses anti-diabetic, anti-cancer, antihyperlipidemic, anti-inflammatory, and anti-hypertensive properties (*Kapravelou et al.*, 2015). Cowpea seeds are consumed boiled either alone or in combination with other foods such as rice, maize, and plantain. According to *Henshaw et al.* (2000) and *Idowu et al.* (2017), cowpeas could be processed into paste or flour for the preparation of various traditional foods such as *akara* (fried cowpea paste), *moin-moin* (steamed cowpea paste), and *gbegiri* (cowpea soup).

Despite cowpea having a wide potential as both a domestic and commercial crop and can be grown in a wide range of soil types, a number of constraints limit its production (*Edokpolor & Beckley*, 2019). These constraints include a lot of factors, especially weeds (*Adusei et al.*, 2016), which are unwanted plants that compete for light, space, soil nutrients, and carbon dioxide, thereby reducing crop yield. Weeds reduce crop yield by releasing allelopathic compounds into the environment (*Fragasso et al.*, 2013; *Marinov-Serafimov et al.*, 2019), thereby providing a conducive environment for pest and virus (*Fisichelli et al.*, 2014). Weeds impose a major constraint on crop production globally, losses caused by weeds alone in cowpea production ranging from 25% to 76% depending on the cultivar and the environment (*Adigun et al.*, 2014; *Gupta et al.*, 2016; *Osipitan et al.*, 2016; *Ugbe et al.*, 2016). Shortcomings brought about by the presence of weeds in cowpea production include reduction in crop yield, less efficient land use, higher cost of production due to insects and plant disease control, reduction in crop quality, water management problems, and less efficient utilization of labour (*Patil et al.*, 2014; *Gatachew et al.*, 2015; *Prabhu et al.*, 2015; *Singh & Sairam*, 2016).

Cowpea-based pudding, indigenously called *Ekuru* or white moin-moin, is a native meal in the south-western part of Nigeria, and it serves as a nutritional food in various cultural, traditional, and religious settings, especially among the

Yoruba people in Nigeria (*Olaleye et al.*, 2018). It is similar to steamed cowpea paste (moin-moin), as both are made from peeled cowpeas only; unlike cowpea-based pudding, steamed cowpea paste (moin-moin) is mixed with pepper and other ingredients before steaming. Cowpea-based pudding is served with fried pepper stew and then mashed up with pepper stew, while some people also enjoy the pudding with fermented maize pudding (*Agidi* or *Eko*), which is also cereal-based food (*Olaleye et al.*, 2018).

Attempt has been made in this particular research to apply some pre-harvest weed control system such as the use of pre-emergence and inter-row spacing so as to reduce post-harvest losses. Therefore, the objective of this study is to determine the effects of the different weed control methods on the physiochemical properties of cowpea flour, proximate composition, physical properties, and sensory qualities of cowpea-based pudding produced from cowpea flour.

2. Materials and methods

The Ife Brown variety of cowpea with three treatments was obtained from the Institute of Food Security, Environmental Resources and Agricultural Research (IFSERAR), Federal University of Agriculture Abeokuta (FUNAAB), Nigeria, while other equipment, such as cabinet dryer, sieve, or blender, was obtained from the Food Processing Laboratory, Department of Food Science and Technology, FUNAAB, Nigeria.

2.1 Treatment of cowpea grains

The cowpea grains obtained were grown with an inter-row spacing of 50 x 75 cm, and weeding was carried out as follows:

– Sample A – supplementary hoe weeding at 6 weeks after sowing (WAS);
– Sample B – two hoe weeding at 3 and 6 weeks after sowing (WAS);
– Sample C – three hoe weeding at 3, 6, and 9 weeks after sowing (WAS).

Preparation of cowpea flour

The cowpea flour was prepared in accordance with the method described by *Idowu et al.* (2017). The cowpea seeds were separated from their husks, dried, weighed, and stored during their processing into flour. Then they were cleaned, soaked, and decorticated. The detached hulls were decanted from the beans. The decorticated cowpea was dried at a temperature of 65°C in a hot air oven (GALLENKAMP SG3-08-169, UK) to a moisture content of 4.0% and dry-milled into flour using laboratory hammer mill (Fritsch, D-55743, Idar-oberstein, Germany). The milled sample was sieved using a 250-μm screen to obtain the flour.

2.2 Physicochemical properties of cowpea flour

2.2.1 Determination of amylose

The amylose content of cowpea flour was determined based on the iodine colorimetric method, as described by *Addy et al.* (2014). About 0.1 g of the starch sample was solubilized with 1 ml of 95% ethanol and 9 ml of 1 M NaOH, and heated in a boiling water bath for 10 min; 1 ml of the extract was made up to 10 ml with distilled water. To 0.5 ml of the diluted extract, 0.1 ml of acetic acid and 0.2 ml iodine solution (0.2 g I_2 + 2.0 g KI in 100 ml of distilled water) were added to develop a dark blue colour. The coloured solution was made up to 10 ml with distilled water and allowed to stand for 20 min for complete colour development. The solution was vortexed, and its absorbance was read on a spectrophotometer (Milton Spectronic 601, USA) at 620 nm. The absorbance of standard amylose with known amylose concentration was used to estimate the amylose content as follows:

$$\%\ \text{Amylose} = \frac{\%\ \text{amylose of standard x Absorbance of sample}}{\text{Absorbance of standard}} \tag{1}$$

2.2.2 Determination of titratable acidity

The method described by AOAC (2012) was used. Twenty-five millimetre of filtrate was transferred into a 125-ml conical flask, a 25-ml burette was filled with 0.1 N NaOH solution adjusted to zero, and then two to three drops of phenolphthalein indicator was added to the conical flask containing the filtrate. The resulting filtrate was then titrated with 0.1 N NaOH until there was a change in colour, and the volume was recorded. Titratable acidity and the volume were recorded. Titratable acidity was calculated as % citric acid:

$$\%\ \text{acid} = \frac{\text{N x V x M}}{\text{S x 10}}, \tag{2}$$

where: N = normality of titrant – usually, 0.1 N NaOH solution is used (mEq/ml); V = volume of titrant (0.1 N NaOH solution) used (ml); M = molecular weight of the predominant acid in the sample divided by the number of hydrogen ions in the acid molecule that are titrated; S = mass of sample (g).

2.2.3 pH determination

The method described by AACC (2000) was used for the determination of pH. Dissolving 30 g of the cowpea flour blends with 90 ml of distilled water, the pH electrode (Thermo Russel RL150, Boston, USA) was placed in the filtrate after being washed with distilled water, and the electrode was allowed to stabilize for a few moments. The pH value of the filtrate was taken after then.

2.2.4 Water absorption capacity

The method described by *Ojinnaka et al.* (2013) was used to determine the water absorption capacity. After weighting 1 g of cowpea flour into a centrifuge tube and mixing it with 10 ml of distilled water, the mixture was left to stand at room temperature for 30 minutes. Thereafter, it was centrifuged (GALLENKAMP Centrifuge Model 90 - 1, USA) at 3,500 rpm for 30 min. The clear supernatant was decanted and discarded. The adhering drops of water in the centrifuge tube were cleaned off with cotton wool, and the tube was weighed. Percentage water absorption capacity was calculated.

2.3 Preparation of cowpea-based pudding from cowpea flour

The method described by *Olaleye et al.* (2018) was used to prepare the cowpea-based pudding. Cowpea flour was poured into a mixing bowl, and 100 ml of warm water was added and mixed thoroughly to form a fluffy paste. It was then scooped into a small bowl with cover, packaged and steam cooked for about 40 min. The samples were then left for cooling for further analysis.

2.4 Proximate composition of cowpea-based pudding

Moisture content, total ash, crude fat, crude fibre, and crude protein were determined using standard methods, as described by AOAC (2012), while total carbohydrate was calculated by difference.

Colour properties of cowpea-based pudding

The method described by *Feili et al.* (2013) and *Oke et al.* (2017) was used. To measure the colour properties of the samples, Minolta Chroma Meter (CR-410, Japan) was used based on (CIE) L* a* b* scale after calibrating the instrument by covering a zero-calibration mask followed by a white calibration plate. Samples were analysed by placing them on a Petri dish, and then the images were captured on the samples. The colour attributes, such as lightness (L*), redness (a*), and yellowness (b*), were recorded.

2.5 Sensory acceptability of cowpea-based pudding

The method described by *Iwe* (2000) was used for the sensory acceptability of cowpea-based pudding. A laboratory-scale sensory acceptability test was conducted, where 30 untrained panellists determined their preference on a nine-point hedonic scale (1 = dislike extremely and 9 = like extremely) in terms of texture, sweetness, crispness, oiliness, and overall acceptance among consumers.

2.6 Statistical analysis

Mean values of triplicate determinations of all the analyses were subjected to one-way analysis of variance (ANOVA) to determine significant differences, and the means were separated using Duncan's multiple-range test at $p < 0.05$.

3. Results and discussions

3.1 Physiochemical composition of cowpea flour

The results for the physicochemical composition of cowpea flour are presented in *Table 1*. The pH values ranged from 4.85 to 5.10. The pH values of all samples were in acidic range, and total titratable acidity (TTA) decreased from 0.05% to 0.02%. The pH value and total titratable acidity showed that acidity decreased as the frequency of hoe weeding increased. Low total titratable acidity of the samples is a proper indication of the good absorption of mineral elements and also an indicator that the product will have a long shelf life because the presence of acidity prevents and/or delays the growth of spoilage microbes (*Abioye et al.*, 2011; *Otunola & Afolayan*, 2018).

There were also significant ($p < 0.05$) differences in water absorption capacity (WAC) and amylose content. The result for WAC values showed a ranged from 276% to 287%. WAC is a very important property in food formulations required for bulking, consistency and in baking applications with an effect on the final product characteristics such as flavour retention, mouthfeel, and shelf life (*Ikegwu et al.*, 2010). The increase in the frequency of hoe weeding led to increase in the capacity of the flour to absorb water by a decrease in values.

The amylose content of the cowpea flours ranged from 22.04% to 24.60%. A higher amylose content has been reported by Kim et al. (2018) in the starch of cowpea and mung bean, in the range of 36%–39%, but cowpea results showed a lower amylose content; this may be due to the cowpea variety type. The amylose content affects the physicochemical properties of starch such as viscosity, swelling power, gelatinization capacity, retrogradation, and starch crystallinity (*Zhenghong et al.*, 2003; *Riley et al.*, 2014).

Table 1. Physicochemical composition of cowpea flour

Samples	pH	TTA (%)	WAC (%)	AMYLOSE (%)
A	5.10 ± 0.14^{b}	0.05 ± 0.01^{ab}	281.40 ± 0.23^{b}	24.60 ± 0.02^{c}
B	4.85 ± 0.07^{a}	0.05 ± 0.01^{ab}	287.09 ± 0.98^{b}	22.85 ± 0.04^{b}
C	5.00 ± 0.00^{ab}	0.02 ± 0.01^{a}	276.00 ± 0.02^{ab}	22.04 ± 0.03^{a}

Notes: Mean values with different superscripts within the same column are significantly different ($p < 0.05$). TTA: total titratable acidity; WAC: water absorption capacity; A – supplementary hoe weeding at 6 WAS; B – two hoe weeding at 3 and 6 WAS; C – three hoe weeding at 3, 6, and 9 WAS.

3.2 Proximate composition of cowpea-based pudding produced from cowpea flour

The proximate composition results of the cowpea-based pudding produced from cowpea flour are presented in *Table 2*. Moisture content results showed an increase in value from 74.26% to 76.15%. The results showed that sample C had the highest value (76.15%) of moisture content and was significantly different ($p < 0.05$) from sample B and sample A, which recorded 75.89% and 74.26% respectively. Sample A had the lowest moisture content when compared to samples B and C, and this is an indicator of good storage stability and longer shelf life. The moisture content obtained in this study was close to the range of 64.90%–69.70% reported by *Bamgboye & Adepoju* (2015). The differences in the moisture content could be attributed to differences between the various bean cultivars and their processing time.

Table 2. Proximate composition of cowpea-based pudding produced from cowpea flour

Samples	Moisture content (%)	Crude fat (%)	Total ash (%)	Crude fibre (%)	Crude protein (%)	Total carbo-hydrate (%)
A	74.26 ± 0.05^{b}	0.71 ± 0.02^{b}	0.94 ± 0.01^{c}	0.75 ± 0.01^{b}	17.83 ± 0.02^{c}	5.55 ± 0.02^{b}
B	75.89 ± 0.05^{c}	0.63 ± 0.00^{a}	0.79 ± 0.01^{b}	0.69 ± 0.01^{a}	16.88 ± 0.06^{b}	5.15 ± 0.02^{a}
C	76.15 ± 0.04^{d}	0.64 ± 0.01^{a}	0.75 ± 0.00^{a}	0.66 ± 0.01^{a}	16.70 ± 0.01^{a}	5.11 ± 0.01^{a}

Notes: Mean values with different superscripts within the same column are significantly different ($p < 0.05$). A – supplementary hoe weeding at 6 WAS; B – two hoe weeding at 3 and 6 WAS; C – three hoe weeding at 3, 6, and 9 WAS.

Results on crude fat showed that sample A had the highest value (0.71%), which was significantly different ($p < 0.05$) from other samples. Sample B had the lowest value (0.63%) of crude fat. The lower fat content of sample B reduces the rate at which rancidity sets in, thereby increasing its shelf life.

Total ash value ranged from 0.75% to 0.94%. Total ash content is an indication of the amount of minerals present in the cowpea-based pudding, which contributes to a specific number of positive functions in the body (*Baah et al.*, 2009). The total ash value of sample C obtained in this study is an indication that sample C is not a good source of mineral.

The high value of crude fibre recorded by sample A (0.75%) is advantageous, as fibre is important in food because it absorbs water and provides roughage for the bowels, aids digestion, lowers the plasma cholesterol level in the body, and prevents several diseases such as irritable colon, cancer, and diabetes (*Elleuch et al.*, 2011; *Idowu et al.*, 2017). The low crude fibre and low protein in sample C is an indicator that the puddings are low-calorie foods that may be very useful in weight management. There were significant differences ($p < 0.05$) in the crude protein content of cowpea-based pudding, that of sample A having the highest (17.85%) and sample C the lowest (16.70%).

The high crude protein observed in sample A (17.83%) could be attributed to the significant quantity of protein (about 24%) in cowpea seed (*Jimoh & Olatidoye*, 2009). The crude protein obtained in this study was higher than the values of 18.80%–21.20% and 16.50%–21.87% reported by *Bamgboye & Adepoju* (2015) and *Olaleye et al.* (2018). This could be due to the differences in the types of legumes used in this study.

The total carbohydrate value ranged from 5.11% to 5.55%, sample A having the highest value. This implies that sample A will provide more glucose to the body when consumed as carbohydrates, which are known to supply glucose to the body, which is then converted to energy used to support various bodily functions and physical activity. Sample A exhibits a higher total ash, crude fibre, and total carbohydrate content when compared with sample B and sample C. Total ash, crude fibre, and carbohydrate content decreases with the increasing frequency of hoe weeding, which means that the nutritional content is low.

3.3 Colour properties of cowpea-based pudding produced from cowpea flour

The colour properties of cowpea-based pudding produced from cowpea flour are presented in *Table 3*. Lightness values ranged from 27.92 to 29.02 while redness values from 7.89 to 9.68. This could be as a result of the process of planting conditions and a significant change in the colour of the seed during the process of soaking and dehulling, while the removal of the seed coat also had a great effect on the colour of the cowpea-based pudding. Sample B recorded the highest yellowness value of 14.11, while sample C recorded the lowest yellowness value of 10.81. The recorded differences in colour properties may be due to the presence of several types of colour constituents (phenolic compounds) present in the cowpea seed (*Sombié et al.*, 2018) used in this study.

Table 3. Colour properties of cowpea-based pudding produced from cowpea flour

Samples	**L***	**a***	**b***
A	29.02 ± 0.03^{c}	9.18 ± 0.04^{b}	13.74 ± 0.08^{b}
B	28.55 ± 0.07^{b}	9.68 ± 0.09^{c}	14.11 ± 0.25^{c}
C	27.92 ± 0.03^{a}	7.89 ± 0.09^{a}	10.81 ± 0.11^{a}

Notes: Mean values with different superscripts within the same column are significantly different ($p < 0.05$). A – supplementary hoe weeding at 6 WAS; B – two hoe weeding at 3 and 6 WAS; C – three hoe weeding at 3, 6, and 9 WAS; L* – lightness; a* – redness; b* – yellowness.

3.4 Sensory score of cowpea-based pudding produced from cowpea flour

Results of the sensory score of cowpea-based pudding are shown in *Table 4*. Significant ($p > 0.05$) differences were not observed in all of the sensory attributes. The texture and the taste ranged from 5.83 to 6.09 and from 5.06 to 6.19 respectively. Cowpea-based pudding produced from sample A had the highest score for texture and taste, while cowpea-based pudding produced from sample C had the lowest score. The colour and appearance ranged from 5.26 to 5.90 and from 5.13 to 5.58 respectively. The low score obtained for the colour and appearance of the cowpea-based pudding could be attributed to the different colour of the cowpea grains. However, the cowpea-based pudding from sample A had the highest score for colour and appearance, while sample B had the lowest score. The aroma ranged between 5.13 and 5.81. The overall acceptability expresses how the consumers or panellists accept the product generally. The overall acceptability ranged from 5.90 to 6.47. It was observed that cowpea-based pudding from sample A and C had the highest overall acceptability, which could be due to the familiarity of the panellist with cowpea-based pudding prepared from cowpea flour.

Table 4. Sensory score of cowpea-based pudding produced from cowpea flour

Samples	Texture	Taste	Colour	Appearance	Aroma	Overall acceptability
A	5.58 ± 1.73^{a}	5.06 ± 1.53^{a}	5.26 ± 1.69^{a}	5.13 ± 1.57^{a}	5.81 ± 1.38^{a}	6.42 ± 1.26^{a}
B	6.03 ± 1.54^{a}	5.55 ± 1.39^{ab}	5.90 ± 1.54^{a}	5.58 ± 1.46^{a}	5.13 ± 1.34^{a}	5.90 ± 1.11^{a}
C	6.09 ± 1.59^{a}	6.19 ± 1.45^{b}	5.84 ± 1.48^{a}	5.50 ± 1.16^{a}	5.69 ± 1.47^{a}	6.47 ± 1.41^{a}

Notes: Mean values with different superscripts within the same column are significantly different ($p < 0.05$). A – supplementary hoe weeding at 6 WAS; B – two hoe weeding at 3 and 6 WAS; C – three hoe weeding at 3, 6, and 9 WAS.

4. Conclusions

The study revealed that the effect of different weed control methods employed significantly affected the performance of cowpea. The physicochemical and proximate composition of the cowpea flour and cowpea-based pudding, respectively, decreased as the frequency of weeding increased. The sensory scores show that cowpea-based pudding produced from cowpea flour with supplementary hoe weeding at 6 WAS and three hoe weeding at 3, 6, and 9 WAS was accepted by the panellist to a lesser degree.

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