IZVORNI ZNANSTVENI RAD / ORIGINAL SCIENTIFIC PAPER

Quality Evaluation of Cowpea-Based Pudding as Influenced by Weed Control Measures

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SAŽETAK

Natjecanje s korovima može smanjiti kvalitetu poljoprivrednih proizvoda, što na kraju utječe na konačne proizvode dobivene od njih. Ovim istraživanjem eksperimentalno je ispitana procjena kvalitete pudinga na bazi graha mahunara (cowpea) pod utjecajem različitih strategija suzbijanja korova. Ispitivane su tri varijante tretmana, dva okopavanja motikom u 3. i 6. tjednu nakon sjetve (WAS – Weeks After Sowing) + razmak između redova 50 cm × 50 cm, tri okopavanja motikom u 3., 6. i 9. tjednu nakon sjetve + razmak između redova 50 cm × 50 cm, varijanta s korovima (bez okopavanja) + razmak između redova 50 cm × 50 cm, te kontrolni uzorak bez ikakvog tretmana. Zrna graha mahunara su oguljena, oprana i samljevena u brašno. Standardnim laboratorijskim tehnikama određene su mineralne i antinutritivne značajke brašna. Smljeveno brašno pretvoreno je u pastu i kuhano na pari 40 minuta kako bi se dobio puding na bazi graha mahunara. Određivana su antinutritivna svojstva (inhibitori tripsina, tanini i fitati) i mineralni sastav (natrij, kalij, magnezij i fosfor) brašna, dok su za puding utvrđivana fizikalna (boja i tekstura) i senzorska svojstva. Vrijednosti inhibitora tripsina, tanina i fitata kretale su se u rasponu 3,46–3,74 %, 0,07–0,10 % i 0,61–0,84 %. Mineralni sastav brašna pokazao je značajan porast natrija i kalija u uzorcima s korovima (weedy check) te razmakom redova 50 × 50 cm, dok je za magnezij, fosfor i kalcij kontrolni uzorak imao najveće vrijednosti. Prema rezultatima, senzorska procjena pudinga pokazala je najveću ukupnu prihvatljivost za kontrolni uzorak (vrijednost 8,39), a zatim za tretman s tri okopavanja u 3., 6. i 9. tjednu nakon sjetve. Rezultati istraživanja pokazuju da su metode suzbijanja korova dovele do povećanja sadržaja natrija i kalija te smanjenja sadržaja kalcija, magnezija i fosfora u brašnu graha mahunara. Antinutritivne komponente brašna povećane su primjenom metoda suzbijanja korova. Senzorska ocjena pokazuje da su metode suzbijanja korova rezultirale pudingom od graha mahunara niže kvalitete u usporedbi s kontrolom.

Ključne riječi: brašno graha mahunara, tjedni nakon sjetve, puding na bazi graha mahunara

ABSTRACT

Weed competition has the capability of lowering the quality of agricultural items which eventually affects final products produced from them. This present study experimentally investigated the quality evaluation of cowpea-based pudding as influenced by strategies to weed control. Three treatments, two hoe weeding at 3 and 6 WAS (Weeks After Sowing)+ 50 cm by 50 cm inter-row spacing, three hoe weeding at 3,6, and 9 WAS + 50cm by 50cm inter-row spacing, and weedy check (no hoe weeding) + 50 by 50 cm inter-row spacing and a control sample without no treatment were evaluated. The cowpea grains were de-hulled, washed, milled to obtain cowpea flour. Using standard laboratory techniques, the cowpea flour's mineral and anti-nutritional qualities were determined. The milled cowpea flour were turned into a paste and steamed for 40 minutes to obtain cowpea-based pudding. Anti-nutritional properties (trypsin inhibitors, tannin and phytate) and mineral composition (sodium, potassium, magnesium and phosphorus) of the cowpea flour was determined while the physical (colour and textural) and sensory properties of the cowpea-based pudding was also determined. The range of values for trypsin inhibitors, tannin and phytate were 3.46-3.74%, 0.07-0.10%, 0.61-0.84% respectively. Mineral composition for cowpea flour showed a significant increase in sodium and potassium for the sample with the weedy check and 50 by 50cm inter-row spacing for magnesium, phosphorus and calcium, the control sample had the highest value. Based on the result, the sensory evaluation of the cowpea-based pudding showed the highest overall acceptability for the control sample with the value 8.39 followed by the treatment three hoe weeding at 3,6 and 9 weeks after sowing. The results of this study indicate that weed control methods led to an increase in sodium and potassium levels and a decrease in calcium, magnesium, and phosphorus levels in cowpea flour. Anti-nutritional compositions of cowpea flour were increased by weed control methods. The sensory score shows that weed control methods resulted into cowpea-based pudding with lower quality compared to the control methods

Keywords: Cowpea flour, weeks after sowing, cowpea-based pudding

INTRODUCTION

Cowpea, also known as *Vigna unguiculata*, is a well-known legume crop that is primarily grown in Africa and is utilized in both human and animal diets all over the world. An edible legume in the *Fabaceae* family, cowpea is also known as black-eye bean or cowgram, southern pea, china bean, bachapin bean, and rope bean (Jonah et al., 2024). Similar to other grain legumes, cowpea is an important food source in tropical and subtropical countries due to its primary use as a grain crop, vegetable, or animal feed (Owade et al., 2020). Cowpea is prized for its ability to withstand drought and it's approximately 25 % protein content (Yahaya et al., 2019). Because of these characteristics, it is an excellent crop for meeting society's requirements for food security.

Cowpea is regarded as an excellent source of numerous other health-promoting components, including phenolic compounds, minerals, soluble and insoluble dietary fiber, and numerous other functional compounds, including B vitamins (Mtolo et al., 2017; Oke et al., 2023). It is present in a wide range of foods and snacks. It can also be eaten whole, preserved in a can, frozen, or ground into flour for baking. For people who are allergic to soybeans, cowpea seeds have been shown to be a better protein source than soybeans in diets with similar protein content.

Steamed cowpea paste known as cowpea-based pudding is popular in Nigeria and other West African nations (Hussein et al., 2020). It fills in as a nourishing food in social, conventional, and strict capabilities particularly among the Yoruba's. The incorporation of air into the paste through whipping during its processing is a crucial step that gave it its distinctive fluffiness and is regarded as one of the product's most important quantity characteristics. Pudding made from cowpeas can be served with vegetable soup or a sauce made with seasonings. However, the majority of people prefer it with corn jellos, which are also foods made from cereal.

Cowpea production can be affected by weeds anywhere from 25% to 76%, depending on the cultivar and the environment. Reduced crop yield, inefficient land use, higher production costs due to insect and plant disease control, decreased crop quality, issues with water management, and less effective labor utilization are all effects of weed in cowpea production (Osipitan, 2017). Weeds primarily lower agricultural output through competing for crop water, soil nutrients, light, and carbon dioxide. Weeds may also lower crop output by dispersing allelopathic substances into the environment and creating a welcoming environment for viruses and pests (Marinov-Serafimov et al., 2019; Oke et al., 2023). Cowpea weed management has relied on outdated methods. This is in part because most of it is grown in developing nations. The choice of weed management methods is heavily influenced by the nature of the weed interference (Osipitan, 2017). The most common physical weed control method for cowpea is hand weeding. The majority of hand weeding is time-consuming, costly, and demanding. An agronomic practice in cowpea is inter-row spacing. The quantity of these practices used can have an impact on cowpea yield levels. However, there is a paucity of information regarding the performance and/or impact of weed and its control methods, physical and cultural control methods on the pudding's quality. Therefore, the study's objective was to assess how weed control measures affected the quality of cowpea-based pudding.

MATERIALS AND METHODS

Materials

Ife brown cowpea grain was obtained at the Institute of Food Security, Environmental Resources and Agricultural Research (IFSERAR), Federal University of Agriculture, Abeokuta, Nigeria. Hot air oven, trays, measuring scale, bowls, and blender were obtained from the Food Processing Laboratory, Federal University of Agriculture Abeokuta, Nigeria

Treatment of cowpea grains

Different treatment combinations (Table 1) were applied to the cowpea before and during propagation. At three, six, and nine weeks after sowing (WAS), treatment 5 underwent two rounds of weeding with a 50 cm x 50 cm inter-row spacing, while the weedy check was not weeded and had the same inter-row spacing.

Table 1. Cowpea grains treatments

Samples	Supplementary weeding	Inter-row spacing
T5	3 and 6 WAS	50cm×50cm
T6	3, 6 and 9 WAS	50cm×50cm
T7 (weedy check)	Nil	50cm×50cm

Where WAS = Weeks after sowing

Processing of cowpea flour

The procedure outlined by Idowu et al. (2017) was followed to process the cowpea flour. The cowpea grains were separated from their husks, dried, weighed and stored, pending the processing into flour. The cowpea seeds were thoroughly cleaned, soaked, and then separated from their hulls. The hulls were removed by pouring them off from the beans. After the hulls were detached, the cowpeas were dried at a temperature of 65°C using a hot air oven, and then ground into flour.

Mineral analysis

The AOAC (2000) method was used to determine the mineral contents of the samples. The most abundant minerals in cowpea, namely calcium, potassium, magnesium, phosphorus, and sodium, were measured using an Atomic Absorption Spectrophotometer. After processing the samples with a perchloric-nitric acid mixture using the AOAC (2000) method, they were analyzed using the Thermo logical S Series Model GE 712354. To prepare the samples for digestion, 4 ml of perchloric acid, 25.00 ml of concentrated HNO_3, and 2.00 ml of concentrated sulfuric acid were added to 0.50 g of the samples in a 125 ml Erlenmeyer flask under a fume hood. The mixture was then gently heated using a Buchi Processing unit K-424 on a hot plate at low to medium intensity under a perchloric acid smoke hood until thick white smoke appeared. After vigorously heating for a quarter of a minute, 50 milliliters of distilled water were added. A Pyrex volumetric flask with a wash bottle was used to completely filter the solution before it was mixed with distilled water after being allowed to cool. The Atomic Absorption Spectrophotometer was then used to measure the solution.

Anti-nutritional composition of cowpea flour

To determine the levels of tannins, phytate, and trypsin inhibitor, the method outlined by Adeyeye et al. (2020) was employed.

Determination of tannin

A beaker containing one gram of each sample was weighed. To extract tannin, each was soaked for five hours in a solvent mixture consisting of 20 mL glacial acetic acid and 80 mL acetone. The filtrates, which were saved for future use, were obtained by filtering the samples through double-layer filter paper. Ten to thirty parts per million (ppm) of tannic acid were added to a standard solution. A Spectronic 20, England spectrophotometer read at 500 nm the absorbances of the standard solution and the filtrates.

Determination of phytate

The procedure involved weighing two grams of each sample into a 250 mL conical flask, followed by soaking each sample with 100 mL of 2% hydrochloric acid for three hours. The resulting solution was then filtered through a double layer of hardened filter paper Whatman No. 3. Next, 50 mL of each filtrate was transferred to a 250 mL beaker and 107 mL of distilled water was added to each solution. An indicator, 10 mL of 0.3% ammonium thiocyanate solution, was added to each beaker, and the resulting solution was titrated with a standard iron (III) chloride solution that contained 0.00195 g of iron per ml. The endpoint of the titration was slightly brownish yellow and persisted for 5 minutes. Finally, the percentage of phytates was calculated using a formula.

$$\%Phytate = \frac{X \times 1.19 \times 100}{0.00195}$$

In the given formula, the value X represents the titre value obtained during the titration process.

Trypsin inhibitor determination

To determine the level of trypsin inhibitor, the samples were weighed into centrifuge tubes with screw caps in two batches, each weighing 0.2 g. Then, 10 mL of 0.1M phosphate buffer was added to the tubes, which were shaken vigorously on a UDY 60 shaker from England for one hour at 25 degrees Celsius. The resulting suspension was then centrifuged at 5000 rpm for 5 minutes and filtered through a Whatman No. 42 paper filter. Each filtrate was reduced to 2 mL in volume using phosphate buffer. To one of the test tubes, 6 mL of 5% trichloroacetic acid (TCA) solution was added as a blank. All the tubes were then placed in a water bath at 37°C, and after 20 minutes, 2 mL of casein solution was added to each tube. After a further 20 minutes, the reaction was stopped by shaking the tubes and adding 6 mL of TCA solution. After one hour at room temperature, the reaction was filtered through a Whatman No. 42 paper filter, and the absorbance of the filtrate from test and trypsin standard arrangements were read at 380 nm using a Spectronic 20 spectrophotometer from Britain. The following formula was used to determine the level of trypsin inhibitor in mg/g of the sample.

Preparation of cowpea-based pudding

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

Colour properties of cowpea-based pudding

The approach outlined by Feili et al. (2013) and Oke et al. (2017) was employed. Using the (CIE) L a b scale, a Minolta chroma meter (CR-410, Japan) was used to measure the samples' colours. Following the application of a white calibration plate and a zero-calibration mask to the instrument for calibration, after the samples were placed in the petri dish for analysis, an image was taken of the samples. Colour attributes such as lightness (L), redness (a), and yellowness (b) were measured.

Textural properties of cowpea-based pudding

The approach by Abdelghafor et al. (2011) was employed. Surface of tests was resolved utilizing Surface Profiles Investigation (TPA). A Testometric Universal Testing Machine (M500-25KN, UK) was used for the TPA. The PC was set for Test works programming and a suitable test was chosen for the TPA investigation. The load cell was slowly brought to a lower level so that the samples could be touched after the samples were placed between the machine's two load cell plates. Before the sample was compressed, parameters like height, diameter, speed, the percentage of compression, and the number of cycles (two) were entered. After that, the load cell began to slowly descend, compressing the sample for five seconds between the first and second compression cycles

Sensory evaluation of cowpea-based pudding

The cowpea-based pudding was subjected to sensory testing in the sensory evaluation laboratory. A nine-point hedonic scale from 0 to 9 was used for sensory evaluation, with 0 representing extreme dislike and 9 representing extreme liking. The product's texture, taste, aroma, color, and overall acceptability were evaluated by the panelists (Iwe 2002).

Statistical Analysis

The collected data was subjected to statistical analysis. Mean values were calculated and an analysis of variance (ANOVA) was conducted using SPSS Version 21.0. To determine significant differences between the mean values, Duncan's multiple range tests was employed.

RESULTS AND DISCUSSIONS

Mineral composition of cowpea flour

The result of the mineral composition of cowpea flour is presented in table 2. The mineral composition of cowpea flour showed significant differences ($p<0.05$) among the samples. Minerals are essential nutrients required in small amounts, typically ranging from less than 1 to 250 mg per day, depending on the specific mineral (Soetan et al., 2010).The sodium content of the cowpea flour ranged from 22.32 to 28.89 mg/100g, weedy check treatment had the highest value for sodium content followed by the three hoe weeding at 3, 6 and 5 WAS treatment while control recorded the lowest value. The sodium content obtained in this study is lower than the values of 30.00- 90.00 mg/100g reported by Bamigoye and Adepoju, (2015); the observed values are consistent with the findings of Osunbitan et al. (2016), who also reported mineral values ranging from 5.73 to 23.70 mg/100g for different types of bean flour. Variations in the values obtained could be as a result of weeding frequency of each sample evaluated in this study. The low sodium content of these legumes makes them a suitable meal option for people with hypertension. Excess sodium can hinder the ability of blood vessels to contract and relax smoothly, and it may also cause overstimulation of heart tissue growth. Sodium helps maintain the body fluids' osmotic pressure by regulating plasma volume and acid–base balance (Murray et al., 2015). Potassium regulates the body's pH, enhances protein and carbohydrate metabolism, and helps to maintain cellular water balance (Onibon et al., 2007). Potassium is an essential nutrient for legumes as it is for other crops. Potassium content ranged from 34.89 to 44.11 mg/100g, the highest value was recorded in treatment 7 (weedy check) followed by treatment 6 (three hoe weeding at 3, 6 and 9 WAS) while the least value was recorded in control. Potassium obtained in this study (34.89-44.11 mg/100g) is lower than the value of 733.03-741.18 mg/100g reported by Inobeme et al. (2014) in white cowpea beans. These values obtained could be due to the planting conditions, crop physiological conditions and treatment of cowpea grains in this study. Cowpea is a good source of potassium, which is essential for protein and amino acid synthesis in the human body, as demonstrated by studies conducted by Alayande et al. (2012) and Inobeme et al. (2014). The magnesium content ranged from 10.12 to 12.97 mg/100g, control sample recorded the highest value, followed by treatment 5 (two hoe weeding at 3 and 6 WAS) while treatment 7 (weedy check) recorded the lowest value. These results are in the range of values 7.67-18.50 mg/100g reported by Owolabi et al. (2012). Among the macro-elements analyzed in this study, magnesium had the lowest values. Cowpea flour with low concentrations of magnesium may be associated with high moisture content of the flour. Magnesium are components of the electrolyte which in synergy help to maintain the body cells and regulation (Beleya and Eke-Ejiofor, 2020). Magnesium is an expected

Table 2: Mineral composition of cowpea flour

Sample	Sodium (mg/100 g)	Potassium (mg/100 g)	Magnesium (mg/100 g)	Phosphorus (mg/100g)
Control	22.32±0.20[a]	34.89±0.03[a]	12.97±0.01[d]	216.12±0.01[d]
T5	24.57±0.00[b]	39.56±0.01[b]	11.69±0.01[c]	182.69±0.00[c]
T6	28.12±0.00[c]	42.19±0.01[c]	10.89±0.00[b]	180.73±0.01[b]
T7	28.89±0.00[d]	44.11±0.00[d]	10.12±0.01[a]	180.02±0.00[a]

Mean values with different superscripts within the same column are significantly different (p<0.05); T5 (Treatment 5) - supplementary weeding of 3 and 6 WAS and inter-row spacing of 50cm×50cm, T6 (Treatment 6) - supplementary weeding of 3, 6 and 9 WAS and inter-row spacing of 50cm×50cm, T7 (Treatment 7) - weedy check i.e., no weeding

Table 3. Anti-nutritional composition of cowpea flour

Sample	Tannin (%)	Phytate (%)	Trypsin Inhibitor (%)
Control	0.07±0.00[a]	0.61±0.01[a]	3.46±0.00[a]
T5	0.08±0.00[b]	0.71±0.01[b]	3.58±0.01[b]
T6	0.09±0.00[c]	0.77±0.01[c]	3.74±0.00[d]
T7	0.10±0.00[d]	0.84±0.00[d]	3.61±0.01[c]

Mean values with different superscripts within the same column are significantly different (p<0.05); T5 (Treatment 5) - supplementary weeding of 3 and 6 WAS and inter-row spacing of 50cm×50cm, T6 (Treatment 6) - supplementary weeding of 3, 6 and 9 WAS and inter-row spacing of 50cm×50cm, T7 (Treatment 7) - weedy check i.e., no weeding

cofactor for in excess of 300 compounds frameworks and is expected for energy creation in the body (Dickson, et al., 2006). The cowpea grains' leaching of minerals during soaking, heat treatment and de-hulling may have led to the Weedy check treatment's lowest magnesium value. The phosphorus content ranged from 180 to 216.12mg/100g, control had the highest value, followed by treatment 5 (two hoe weeding at 3 and 6 WAS) while weedy check treatment recorded the lowest value. Phosphorus is a crucial component of adenosine triphosphate (ATP) and nucleic acids, and it is vital for maintaining acid-base balance as well as forming bones and teeth (Soetan et al., 2010). The high values (180 to 216.12 mg/100g) of phosphorus in this study may be due to the fact that phosphorus is the most abundant mineral element found in the varieties of cowpea. The significant decrease in phosphorus content may be due to different soil conditions of the cowpea seeds (Pugalenthi et al., 2005). Also, levels of phosphorus, potassium and manganese vary widely due to environmental conditions (Adeboye and Singh, 2007). Growth plate cartilage mineralization and delayed vascular invasion are both caused by phosphorus deficiency (Penido et al., 2012). The calcium content ranged from 146.98 to 154.21mg/100g, the highest value was recorded in control, followed by treatment 5 while treatment 6 recorded the lowest value. The result of calcium in this study is higher than the values of 7.53-7.75mg/100g reported by Adeboye and Singh (2007) on the levels of minerals in cowpea decorticated grain. The reduction in calcium could be due to oxidation and leaching out of the mineral element during the drying process. The study observed that the variations in calcium levels could be attributed to the soil type and location where the cowpea was cultivated as soil mineral content influences the absorption of minerals by the plants. However, in this study, the cowpea seeds were planted in the same location, and therefore, the disparity in calcium content could be attributed to the treatment conditions. Calcium in conjunction with magnesium, phosphorus and protein are involved in bone formation (Zaneta et al., 2021). Calcium is an essential mineral that is required in significant amounts by humans and other vertebrates for various physiological processes, including the production and repair of bone and the normal function of nerves and muscles (Soetan et al. 2010).

A lack of calcium in the body can cause a bone disease called Osteoporosis, which is a significant health concern for the public (Zaneta et al., 2021).

Anti-nutritional composition of cowpea flour

The result of the anti-nutritional composition of cowpea flour is presented in Table 3. Anti-nutrients are plant compounds—natural or manufactured—that make it harder for the body to digest and absorb essential nutrients like protein, vitamins, and minerals. The weedy check treatment had the highest tannin content, ranging from 0.07 to 0.10%, while the control treatment had the lowest. The tannin values recorded in this study is lower than the values of 18.09mg/100g reported by Ndidi et al. (2014) on African Yam Bean. It has been demonstrated that handling reduces the tannin level of the majority of food sources, improving iron's bioavailability. De-hulled cowpea's tannin content may be decreased by milling and husk separation, enhancing the product's nutritional value. This study's low tannin content is due to the fact that tannin is primarily found in the testa or seed coats of cowpea (Ikhlas and Sirelkhatim, 2016). Afiukwa (2012) reported that environmental effects were the major source of variation for tannins. The increase in tannin content could be due to an increase in weeding frequency of cowpea grains during cultivation before being processed into cowpea flour. However, cooking decreases tannins due to the fact that these compounds are heat labile and degrade upon heat treatment (Makinde and Abolarin, 2020).Tannins has been accounted for to influence protein edibility, unfavorably impacting the bio-accessibility of non-heme iron prompting unfortunate iron and calcium retention, likewise starch is impacted prompting decreased energy worth of an eating regimen (Adeparusi, 2001; Gemade et al., 2016). However, it is essential to keep in mind that tannins' toxicity is determined by their chemical structure and dosage (Bello et al., 2008). The toxic effects of tannin reported in other literature on cowpea flour may not be a concern since the acceptable intake of tannic acid for a man is 560 mg/100g as reported by Bello et al. (2008).

Phytate is a type of complex compound that occurs naturally and has the ability to greatly impact the functional characteristics of food. Phytic content ranged from 0.61 to 0.84%, treatment 7 recorded the highest value while control recorded the lowest value. These values are much less than those observed in four Indian cowpea cultivars (360 to 780 mg/100g) reported by Yadav et al. (2015). Dehulling and phytic acid's heat liability may have contributed to this study's low phytic acid concentration (Makinde et al., 2020). However, phytic acid is more tolerant of heat cooking than any other anti-nutritional factors (Abizari et al., 2012). Phytate for the most part tie multivalent cations, structure edifices with proteins, starch and minerals, for example, iron, zinc, calcium and magnesium in this way are less filtered contrasted with tannin that were promptly solvent in water. Contrasted with a phytate diet comprising 10–60 mg/100g, which when ingested over an extended period of time has been found to reduce mineral bioavailability, cowpea flour samples' phytate amounts might not be dangerous (Elinge et al., 2012). On the plus side, there is proof that dietary phytate may be useful as an antioxidant, anti-carcinogen, and presumably play a significant role in preventing hypercholesterolemia and atherosclerosis at low levels (Adeparusi, 2001).

One of the most significant anti-nutritional elements found in plants, especially in legumes, is trypsin inhibitor, which has been shown to interfere with the digestion process and may cause adverse physiological effects (Karim et al., 2018).The trypsin inhibitor content ranged from 3.46 to 3.74%, the highest value was recorded in weedy check treatment and the lowest value in two hoe weeding at 3 and 6 WAS. The trypsin inhibitor value observed in this study is lower than the values reported by Afiukwa et al. (2012) which ranged from 19.16 – 23.79 mg/100g for anti-nutrient contents of different cowpea cultivars. The fact that cowpea seeds were soaked may have contributed to the low trypsin inhibitor value because soaking was shown to be more effective at removing trypsin inhibitors from cowpea seeds (Goncalves et al., 2016 and Diouf et al., 2019). According to Bolade (2015), the overall decrease in trypsin inhibitor activity was influenced in varying degrees by each unit operation involved in the preparation of cowpea flour. The control recorded the lowest value in trypsin inhibitor. Climate, irrigation, seed genotype and soil type all influence anti-nutrient concentrations in seeds (Urbano et al., 2000). Variation in anti-nutrient concentrations is the most important factor of the cowpea flour could be also related to the individual treatment (weeding) of the cowpea grains in this study.

Colour properties of cowpea-based pudding

Table 4 presents the outcome of the cowpea-based pudding's colour qualities. There was a significant difference ($p<0.05$) in the colour of cowpea-based pudding. The values of lightness ranged from 19.30 to 32.47, treatment 7 recorded the highest value while treatment 6 recorded the lowest value. Redness ranged from 8.54 to 10.38, control recorded the highest value while treatment 6 recorded the lowest value. This could be attributed to the planting conditions and a significant change in the seed's colour during the process of soaking and dehulling; additionally, the removal of the seed coat significantly altered the colour of the cowpea-based pudding. Adekunte et al. (2010) categorize perceived colour differences (E) into three categories: extremely big (E>3), big (1.5E3), and modest (1.5E). The big colour difference could be easily seen (Table 5). Yellowness ranged from 11.39 to 18.23, treatment 7 recorded the highest value while treatment 6 recorded the lowest value. It's possible that a variety of colour constituents are to blame for the observed variations in colour parameters (i.e. phenolic compounds) present in legumes. The study observed a range of 17.20 to 21.69 in the change of energy, with the highest value recorded in treatment 7 and the lowest in treatment 6. The result revealed that treatment 6 recorded the lowest values in all colour properties, while the highest value was recorded in treatment 7 except for redness. Significant ($p<0.05$) difference was observed along all treatment levels in lightness, yellowness and change of energy but not so for redness, samples treatment 5 and treatment 6 had no significant ($p>0.05$) difference in redness.

Textural properties of cowpea-based pudding

Table 5 displays the textural characteristics of pudding made from cowpeas. The force required to achieve a given deformation is what is meant by the term "hardness". The result of hardness in this study ranged from 9.89-134.61 N, treatment 6 recorded the highest value of hardness while treatment 5 recorded the least hardness. According to Enwere and Hung (2000), the hardness of cowpea-based pudding can be affected by factors such as drying temperature and wet milling. The observed decrease probably resulted from the alterations of the protein and starch because of the effect of heat during drying (Enwere et al., 1998; Enwere and Hung, 2000). Considering that starch is a major constituent of cowpea-based pudding; the stabilization of amylose in the helical form and the formation of an amylose-lipid complex may be related to softening (Cardoso et al., 2022). The measure of cohesiveness, or the strength of the internal linkages that make up the product's body, is the ratio of positive force during the second compression cycle to that during the first compression cycle. In this study, the cohesiveness value indicates how well cooked cowpea resists a second deformation in comparison to its resistance during the first deformation. Cohesiveness of the cowpea-based pudding ranged from 0.15-0.23 N, treatment 6 recorded the lowest value while treatment 7 (weedy check) recorded the highest.

The ability of foods to bounce back after a few bites is known as springiness. It is stated as a ratio or as a percentage of the initial height of the product. It organoleptically illustrates how well the cowpea-based pudding actually recovers after being damaged during the main pressure and after being allowed to wait for the intended pause between strokes. The results of this study's springiness test ranged from 0.18 to 0.48, with control recording the highest value and treatment 5 (two hoe weeding at 3 and 6 WAS) recording the lowest value. These results confirm the cowpea-based pudding's fragile, brittle, and soft nature, which was already implied by the hardness and gumminess values. Stickiness/Gumminess is the energy expected to separate a semi-strong nourishment for gulping, which can be determined by increasing the hardness by the cohesiveness.

Chewiness ranged from 0.32-7.00N with treatment 6 (three hoe weeding at 3, 6 and 9 WAS) recording the highest value. A comparable variance

Table 4. Colour properties of cowpea-based pudding

Sample	L	a	b	E
Control	31.70 ± 0.11^{c}	10.38 ± 0.13^{c}	15.74 ± 0.19^{c}	19.60 ± 0.31^{c}
T5	22.39 ± 0.12^{b}	8.60 ± 0.24^{a}	13.14 ± 0.07^{b}	17.69 ± 0.07^{b}
T6	19.30 ± 0.11^{a}	8.54 ± 0.07^{a}	11.39 ± 0.12^{a}	17.20 ± 0.03^{a}
T7	32.47 ± 0.04^{d}	10.04 ± 0.09^{b}	18.23 ± 0.09^{d}	21.69 ± 0.03^{d}

Mean values with different superscripts within the same column are significantly different ($p<0.05$). L = Lightness, a = Redness; b = Yellowness; E = Change in Energy; T5 (Treatment 5) - supplementary weeding of 3 and 6 WAS and inter-row spacing of 50cm×50cm, T6 (Treatment 6) - supplementary weeding of 3, 6 and 9 WAS and inter-row spacing of 50cm×50cmT7 (Treatment 7) - weedy check i.e., no weeding

Table 5: Textural properties of cowpea-based pudding

Sample	Hardness (N)	Springiness	Cohesiveness	Chewiness (N)	Fracturability (N)
Control	76.86±0.67^{b}	0.48±0.03^{c}	0.19±0.00^{ab}	6.86±0.61^{b}	68.27±1.06^{b}
T5	9.89±0.31^{a}	0.18±0.02^{a}	0.18±0.01^{a}	0.32±0.04^{a}	0.00±0.00^{a}
T6	134.61±7.37^{b}	0.34±0.06^{b}	0.15±0.02^{a}	7.00±3.40^{b}	117.65±3.37^{c}
T7	22.84±0.60^{a}	0.23±0.04^{b}	0.23±0.02^{b}	1.69±0.11^{a}	0.00±0.00^{a}

Mean values with different superscripts within the same column are significantly different ($p<0.05$); T5 (Treatment 5) - supplementary weeding of 3 and 6 WAS and inter-row spacing of 50cm×50cm, T6 (Treatment 6) - supplementary weeding of 3, 6 and 9 WAS and inter-row spacing of 50cm×50cm, T7 (Treatment 7) - weedy check i.e., no weeding

Table 6: Sensory score of cowpea-based pudding

Sample	Texture	Taste	Colour	Appearance	Aroma	Overall Acceptability
Control	8.06±0.96^{c}	8.00±0.93^{d}	7.68±1.30^{b}	7.94±1.06^{c}	8.13±0.99^{c}	8.39±0.72^{c}
T5	5.35±1.33^{a}	4.87±0.99^{a}	5.35±1.47^{a}	4.71±1.75^{a}	4.87±1.48^{a}	5.61±1.05^{a}
T6	6.65±1.05^{b}	6.48±1.12^{c}	5.74±1.39^{a}	5.71±1.16^{b}	5.42±1.09^{ab}	6.68±0.70^{b}
T7	6.07±1.39^{b}	5.83±1.56^{b}	5.80±1.40^{a}	6.13±1.17^{b}	5.87±1.14^{b}	6.60±0.81^{b}

Mean values with different superscripts within the same column are significantly different ($p<0.05$); T5 (Treatment 5) - supplementary weeding of 3 and 6 WAS and inter-row spacing of 50cm×50cm, T6 (Treatment 6) - supplementary weeding of 3, 6 and 9 WAS and inter-row spacing of 50cm×50cm, T7 (Treatment 7) - weedy check i.e., no weeding

in the amount of time needed to chew cowpea-based pudding before swallowing should be anticipated given the significant degree of chewiness variation. The effort required to remove the mashed food from a probe surface is referred to as adhesiveness. It's a way to tell how sticky certain products are. It could likewise be portrayed as the work expected to conquer the tacky powers between the example and the test (Trinh and Glasgow, 2012). The range of adhesiveness values observed in this study was between 0.47 – 1.02 N.S. Treatment 5 had the highest adhesiveness value, while the control had the lowest. Higher value of adhesion may imply that the product may have been overcooked to the point of stickiness. The findings of this study suggest that cowpea-based pudding has a low adhesiveness and therefore does not stick to the palate.

Fracturability is the force required to crack the cooked cowpea-based pudding. It also imitates the first bite force of the product during the commencement of chewing. Fracturability ranged from 0.00-117.65 N, treatment 5 recorded the lowest value while treatment 6 recorded the highest. Fracturability encompasses crumbliness, crispiness, crunchiness and brittleness. The fact that there were no values for fracturability suggested that the hard-to-cook phenomenon might not have been as prominent in the pudding made from cowpeas. Significant ($p<0.05$) difference was observed along all treatment levels for springiness but not so for other textural properties, though some treatments were significantly different from other.

Sensory score of cowpea-based pudding

The result of the sensory score of cowpea-based pudding is shown in Table 6. Evaluation of the texture was based on hand feeling, appearance and consistency of a substance. The texture score ranged from 5.35 to 8.06, treatment 5 had the least value while control had the highest value for texture. In terms of taste score, the range observed in this study was from 5.35 to 8.00. Sample 5 received the lowest taste score, while the control sample had the highest taste score. The values for colour range from 5.35 to 7.68, the appearance ranged from 4.71 to 7.94, aroma ranged from 4.87 to 8.13 and the overall acceptability ranged from 5.61 to 8.39.These have an impact on the pudding's moisture, mouthfeel and appearance, making them important distinguishing characteristics. One of the most important qualities to look for in a product is taste, which is the flavor that is felt in the mouth and throat when a substance is touched. Since there was uniformity in the preparation of the cowpea-based pudding, the variation in taste depends on the composition of the raw materials used in the preparation of the samples.

CONCLUSION

The results of this study indicate that weed control methods led to an increase in sodium and potassium levels and a decrease in calcium, magnesium, and phosphorus levels in cowpea flour. Anti-nutritional compositions of cowpea flour were increased by weed control methods. Textural properties of cowpea-based pudding such as hardness, springiness, cohesiveness, chewiness, fracturability and gumminess were increased by weed control methods, while adhesiveness was reduced. According to panelists rating, weed control methods resulted in cowpea-based pudding with lower quality compared to the control, since control was rated best overall for sensory attributes of the cowpea based on pudding.

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