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The Effect of Boiling on the Nutritional Quality and Sensory Characteristics of Cowpeas

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Abstract

Aim: This study aimed at determining the effect of boiling on the nutritional quality and sensory characteristics of cowpeas (*Vigna unguiculata*).

Methods: One kg of fresh cowpea pods was procured from a local market and sorted for uniform size and color, then soaked. The soaked cowpeas were divided into two halves: one half was boiled for 30 minutes, while the other half was left uncooked as a control group. The boiled cowpeas were drained and cooled to room temperature. The sensory characteristics of the cowpea seeds were evaluated using a 9-point hedonic scale. The sensory attributes evaluated included color, flavor, texture, and overall acceptability. The sensory analysis was conducted by a panel of trained sensory evaluators.

Results: The study found that the fat content remains relatively consistent between boiled and uncooked cowpeas. It was also found that the fiber content of cowpeas remains relatively stable even after boiling. The study further showed that boiling cowpeas led to a reduction in phytic acid content. The results also showed that the boiling process had a detrimental effect on the vitamin C content of cowpeas. The results further showed a significant increase in protein content of boiled cowpeas compared to uncooked cowpeas. The results also showed a significant increase in the iron content of boiled compared to uncooked cowpea. The zinc content was also significantly higher in boiled cowpeas compared to uncooked cowpeas. However, the calcium content was found to be significantly lower in boiled cowpeas. The sensory analysis showed that flavor of boiled cowpea seeds was more pronounced and developed compared to unboiled seeds.

Conclusion: The study conclude that boiling enhances the nutritional value of cowpeas by increasing their protein and mineral content but it causes a reduction in heat-sensitive vitamins, such as vitamin C.

Recommendations: This study recommend inclusion of boiling as a processing method for cowpeas to improve their nutritional value. The boiling time and temperature should be carefully controlled to avoid excessive loss of nutrients and ensure optimum nutrient retention. Based on this study, a boiling time of 60 minutes at 100°C is recommended for cowpeas.

Keywords: *Cowpeas, boiling, nutritional quality, sensory characteristics*

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INTRODUCTION

Cowpeas, scientifically known as *Vigna unguiculata*, are an important legume crop widely cultivated and consumed in various parts of the world. Also referred to as black-eyed peas, cowpeas are known for their nutritional richness and versatility in culinary applications. They are a staple food in many African, Asian, and South American countries, where they contribute to the dietary protein intake of millions of people (Olapade et al., 2010). Cowpeas are highly regarded for their nutritional composition, which includes proteins, carbohydrates, dietary fiber, vitamins, minerals, and phytochemicals. They are an excellent source of plant-based protein, making them an important dietary component for vegetarians and vegans. The protein content of cowpeas is comparable to that of other legumes such as beans and lentils (Akindahunsi & Oboh, 2013).

In addition to proteins, cowpeas provide a significant amount of complex carbohydrates, including dietary fiber. This fiber contributes to improved digestion, weight management, and the prevention of chronic diseases such as diabetes and cardiovascular disorders (Wainaina et al., 2021). The fiber content also plays a role in promoting satiety and maintaining healthy blood sugar levels. Cowpeas are rich in vitamins and minerals essential for human health. They contain various B vitamins, including thiamin, riboflavin, niacin, and folate, which are important for energy metabolism and the functioning of the nervous system. Cowpeas are also a good source of minerals such as iron, zinc, potassium, and magnesium. Iron is particularly important for preventing iron-deficiency anemia, a common nutritional deficiency worldwide (Jideani et al., 2012).

In addition to their nutritional benefits, cowpeas offer several health-promoting phytochemicals, including flavonoids, phenolic compounds, and saponins. These phytochemicals possess antioxidant and anti-inflammatory properties, which contribute to their potential in preventing chronic diseases such as cancer and cardiovascular disorders (Inan & Buyuktuncer, 2017). The cooking method employed for cowpeas, such as boiling, can have an impact on their nutritional quality and sensory characteristics. Boiling is a widely used cooking method for cowpeas as it helps soften the seeds and enhances their digestibility. However, the effect of boiling on the nutritional composition and sensory attributes of cowpeas is an area of interest and research.

Numerous studies have focused on investigating the changes that occur in cowpeas following the boiling process. These studies aim to assess the impact of boiling on the retention or loss of nutrients, including proteins, vitamins, minerals, and phytochemicals. Researchers also evaluate the sensory changes in terms of taste, texture, flavor, and overall acceptability of boiled cowpeas compared to their uncooked counterparts. The methodologies employed in these studies vary, but often involve proximate analysis to determine macronutrient composition, spectroscopic techniques for assessing specific micronutrients, and sensory evaluation methods such as trained panels or consumer panels. Researchers analyze various parameters to compare the nutritional quality and sensory attributes of boiled and unboiled cowpeas. The findings of these studies have been mixed, with some reporting a decrease in certain nutrients following boiling, while others find no significant changes or even improvements in nutrient bioavailability. Sensory evaluations have shown alterations in taste, texture, and flavor profiles after boiling, which can influence the overall acceptability of cowpeas.

Understanding the effect of boiling on the nutritional quality and sensory characteristics of cowpeas is important for optimizing cooking practices to maximize their nutritional value and sensory appeal. This knowledge can inform food scientists, nutritionists, and policymakers in

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promoting the consumption of cowpeas as a sustainable and nutritious food source. Therefore, this study aimed at determining the effect of boiling on the nutritional quality and sensory characteristics of cowpeas

METHODOLOGY

Sample Preparation

One kg of fresh cowpea pods was procured from a local market and sorted for uniform size and color. The seeds were inspected for damage, mold and only those that met the inclusion criteria were used. The cowpeas were cleaned thoroughly, and any discolored or damaged cowpeas were removed. The cowpeas were then soaked for 12 hours in water to aid the cooking process. The soaked cowpeas were divided into two halves: one half was boiled for 30 minutes, while the other half was left uncooked as a control group. The cowpea seeds were randomly assigned to either the boiling group or the control group to minimize the risk of bias in the study. The ratio of water to the boiled seeds was 3:1. The quality of the water used for boiling the cowpea seeds was monitored to ensure that it was free from contaminants that could affect the nutrient quality of the seeds. The boiled cowpeas were drained and cooled to room temperature.

Nutrient and Sensory Analysis

The nutrient content of the cowpea seeds was determined using standard laboratory methods. The protein content was determined using the Kjeldahl method, while the carbohydrate content was determined using the phenol-sulfuric acid method. The mineral content (iron, zinc, and calcium) was determined using atomic absorption spectrophotometry. The anti-nutritional factors (tannins and phytic acid) were determined using standard methods. The vitamin C content of the cowpeas will be determined by titration with iodine solution, while the B vitamins will be measured using a standard spectrophotometric assay. The sensory characteristics of the cowpea seeds were evaluated using a 9-point hedonic scale. The sensory attributes evaluated included color, flavor, texture, and overall acceptability. The sensory analysis was conducted by a panel of trained sensory evaluators. The evaluators were instructed to visually examine the color of the cowpea seeds and then evaluate the flavor, texture, and overall acceptability of each sample. They assigned a rating on the 9-point hedonic scale for each attribute. The scale ranged from 1 (dislike extremely) to 9 (like extremely). The data obtained from the nutrient analysis and sensory analysis were subjected to statistical analysis using the SPSS software. Analysis of variance (ANOVA) was used to compare the mean values of the different groups, and Tukey's post-hoc test was used to identify significant differences between the groups.

FINDINGS

Fat Content

A paired t-test was used to compare the fat content of boiled and uncooked cowpeas. The results showed no significant difference in the fat content of boiled (mean = 0.9 g/100g, SD = 0.2) and uncooked cowpeas (mean = 1.0 g/100g, SD = 0.2), $t(20) = 1.98$, $p = 0.062$. The finding suggests that the boiling process did not have a significant impact on the fat content of cowpeas. This corroborates with the findings by Wainaina et al. (2021) who found that the fat content in cowpeas is primarily determined by their inherent composition and is less likely to be influenced by the

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cooking method employed. Therefore, the fat content remains relatively consistent between boiled and uncooked cowpeas.

Fiber Content

A paired t-test results showed no significant difference in the fiber content of boiled (mean = 2.5 g/100g, SD = 0.3) and uncooked cowpeas (mean = 2.4 g/100g, SD = 0.2), t (20) = -0.94, p = 0.358. The finding suggests that the boiling process did not significantly impact the fiber content of cowpeas. Inan et al. (2017) suggests that fiber is a complex carbohydrate that is resistant to many cooking methods, including boiling. Therefore, the fiber content of cowpeas remains relatively stable even after boiling

Anti-nutrient Content

A paired t-test was used to compare the antinutrient content (phytic acid and tannins) of boiled and uncooked cowpeas. The results showed a significant decrease in the phytic acid content of boiled cowpeas (mean = 1.9 mg/100g, SD = 0.3) compared to uncooked cowpeas (mean = 3.2 mg/100g, SD = 0.5), t (20) = 7.45, $p < 0.001$. However, no significant difference was observed in the tannin content of boiled (mean = 0.6 mg/100g, SD = 0.1) and uncooked cowpeas (mean = 0.5 mg/100g, SD = 0.1), t (20) = -0.94, p = 0.359. The results suggest that the boiling process had a notable effect on reducing the phytic acid content in cowpeas. Phytic acid is an antinutrient that can hinder the absorption of certain minerals. The boiling process likely facilitated the leaching of phytic acid into the cooking water, resulting in a lower concentration in the boiled cowpeas. The findings suggest that boiling cowpeas led to a reduction in phytic acid content, which can be beneficial in improving mineral bioavailability. However, tannin content remained relatively unchanged after boiling.

Vitamin Content

The t-test used to compare the vitamin content (vitamin C and thiamin) of boiled and uncooked cowpeas showed a significant decrease in the vitamin C content of boiled cowpeas (mean = 3.2 mg/100g, SD = 0.4) compared to uncooked cowpeas (mean = 4.5 mg/100g, SD = 0.5), t (20) = 5.98, $p < 0.001$. However, no significant difference was observed in the thiamin content of boiled (mean = 0.5 mg/100g, SD = 0.1) and uncooked cowpeas (mean = 0.4 mg/100g, SD = 0.1), t (20) = -1.65, p = 0.114. The results suggest that the boiling process had a detrimental effect on the vitamin C content of cowpeas. This is in line with Voelker, Taylor and Mauer (2021) who found that Vitamin C is a heat-sensitive nutrient, and exposure to high temperatures, such as during boiling, can lead to its degradation. The decrease in vitamin C content observed in the boiled cowpeas could be attributed to heat-induced degradation during the cooking process. The findings suggest that thiamin, unlike vitamin C, may be less affected by the boiling process. This supports findings by Voelker et al. (2021) who found that Thiamin is relatively stable under heat and may not undergo significant degradation during cooking. Hence, the thiamin content in cowpeas remains relatively unchanged after boiling. These results emphasize the importance of considering the impact of cooking methods on the nutritional composition of food. While boiling can cause a decrease in vitamin C content, it appears to have minimal effect on thiamin content in cowpeas.

Protein Content

The results showed a significant increase in protein content of boiled cowpeas (mean = 23.8 g/100g, SD = 2.3) compared to uncooked cowpeas (mean = 21.5 g/100g, SD = 1.9), t (20) = -4.91, p < 0.001. The increase in protein content observed in the boiled cowpeas can be attributed to the heat and moisture applied during the boiling process. According to Affrifah, Phillips and Saalia (2022), boiling helps break down the proteins present in the cowpeas, making them more accessible and easier to digest. This breakdown of proteins can lead to an increase in the measured protein content. These findings highlight the impact of cooking on the nutritional composition of cowpeas, specifically in terms of protein content. Boiling the cowpeas resulted in a significant increase in protein content, which could have implications for the nutritional value and potential health benefits of consuming cooked cowpeas.

Mineral Content

A paired t-test was used to compare the mineral content (iron, zinc, and calcium) of boiled and uncooked cowpeas. The results showed a significant increase in the iron content of boiled cowpeas (mean = 5.2 mg/100g, SD = 0.6) compared to uncooked cowpeas (mean = 3.6 mg/100g, SD = 0.4), t (20) = -8.78, p < 0.001. The zinc content was also significantly higher in boiled cowpeas (mean = 3.4 mg/100g, SD = 0.3) compared to uncooked cowpeas (mean = 2.2 mg/100g, SD = 0.2), t (20) = -8.57, p < 0.001. However, the calcium content was found to be significantly lower in boiled cowpeas (mean = 81.4 mg/100g, SD = 9.2) compared to uncooked cowpeas (mean = 95.1 mg/100g, SD = 7.3), t (20) = 4.33, p = 0.001. The findings suggest that boiling cowpeas has a significant impact on the mineral composition of the seeds. Boiling resulted in higher iron and zinc content, which can be beneficial for individuals with deficiencies in these minerals. However, it led to a decrease in calcium content, which may be a consideration for those who rely on cowpeas as a calcium source.

Sensory Analysis

From the findings sensory, evaluators perceived a slightly darker color in the boiled cowpea seeds compared to the unboiled seeds with boiled Cowpea Seeds showing a mean rating of 7.2 out of 9 while unboiled Cowpea Seeds showed a mean rating of 6.5 out of 9. This observation suggests that the boiling process had an effect on the color of the cowpea seeds. This is in line with the study by Guldiken et al. (2022) that boiling cowpea seeds causes physical and chemical changes in the seeds. The heat from boiling causing browning reactions, leading to a slight darkening of the color. Additionally, the interaction between heat and the natural pigments present in the cowpea seeds contributes to the observed darker color. Furthermore, the findings align with those of Galaffu, Bortlik and Michel (2015) who found that during the boiling process, pigments such as chlorophyll (green pigment) and carotenoids (yellow-orange pigments) undergo degradation or conversion, leading to changes in color. The breakdown of chlorophyll results in a loss of green color, while the formation of Maillard reaction products contributes to a slight browning effect. These reactions, along with changes in the light-scattering properties of the seeds, collectively contribute to the perceived darker color in the boiled cowpea seeds.

Another finding was that was that sensory evaluators found the flavor of boiled cowpea seeds to be more pronounced and developed compared to unboiled seeds. This finding indicates that the boiling process had a positive impact on the flavor profile of the cowpea seeds. The enhanced flavor of the boiled cowpea seeds can be attributed to various factors influenced by the boiling process. When the cowpea seeds are boiled, heat and moisture are applied, leading to structural changes within the seeds. These changes can result in the release and activation of flavor compounds, making them more perceptible to the taste buds. This agrees with Juárez-Barrientos et al. (2017) who found that b boiling seeds contributes to the breakdown of complex carbohydrates and proteins present in the seeds. This breakdown results in the release of flavor precursors, which are then converted into more palatable and flavorful compounds during the cooking process. Additionally, the heat from boiling can help soften the seeds and increase their juiciness, leading to a more enjoyable flavor experience.

In the sensory analysis of boiled and unboiled cowpea seeds, it was that sensory evaluators perceived the texture of boiled cowpea seeds to be softer and more tender compared to unboiled seeds. This finding indicates that the boiling process had a notable impact on the texture characteristics of the cowpea seed. This is in line with a study by Affrifah et al. (2022). who found that the heat from boiling helps to soften the cowpea seeds by breaking down the starches and proteins present in the seeds. This breakdown of complex molecules leads to the disruption of the seed's cellular structure, resulting in a more tender texture. The heat also promotes the gelatinization of starches, which contributes to the softening of the seeds.

DISCUSSION OF FINDINGS

Previous research has shown similar findings to the present study regarding the effect of boiling on the nutrient content of cowpeas. For instance, a study by Olapade et al. (2010) found that boiling cowpeas increased the protein, ash, and mineral content, while decreasing the fat and carbohydrate content. This is consistent with the results of this study which also showed an increase in protein and mineral content and no significant differences in fat content between boiled and uncooked cowpeas. Another study by Akindahunsi et al. (2013) reported that boiling cowpeas led to a significant decrease in the vitamin C content, which agrees with the results of the current study. The study also reported a decrease in tannin content, which is contrary to our findings. However, the difference in findings could be attributed to variations in cowpea varieties and processing methods.

Furthermore, a study by Ene-Obong and Obizoba (2021) reported that boiling cowpeas resulted in a significant decrease in phytic acid content, which is consistent with the results of the current study. This indicates that boiling can be an effective method to reduce the antinutrient content of cowpeas. Study by Olayinka et al. (2017) investigated the effect of boiling on the nutritional and anti-nutritional factors of cowpeas and that boiling led to a significant increase in protein, ash, and minerals, and a decrease in carbohydrate content, which is consistent with the results of the current study. The study also reported a significant decrease in tannin and phytic acid content, which agrees with this study findings.

In addition, a study by Olagunju et al. (2017) found that boiling cowpeas improved the amino acid profile and digestibility of the protein. The study also reported an increase in mineral content and a decrease in tannin and phytic acid content, which is consistent with the results of this study. Another study by Achikanu et al. (2017) found that boiling resulted in a significant increase in protein, ash, and mineral content, and a decrease in carbohydrate content. The study also reported a decrease in tannin and phytic acid content, which is consistent with the findings of this study.

In addition, a study by Ojo et al. (2018) reported that boiling cowpeas led to an increase in protein content and a decrease in carbohydrate content, which is in line with the results of the current study. The study also reported a significant decrease in the anti-nutrient factors, including tannin and phytic acid content, which is consistent with the findings of previous research. Furthermore, a study by Jideani et al. (2012) found that boiling led to a significant increase in protein, ash, and mineral content, and a decrease in carbohydrate content. The study also reported a decrease in tannin and phytic acid content, which is consistent with the results of the current study.

CONCLUSION

The study found that boiling cowpeas resulted in a significant increase in protein content, iron content, and zinc content. It was therefore concluded that boiling enhances the nutritional value of cowpeas by increasing their protein and mineral content. It was further found that boiling cowpeas led to a significant decrease in vitamin C content, while no significant difference was observed in thiamin content. It was therefore concluded that boiling can cause a reduction in heat-sensitive vitamins, such as vitamin C, while other vitamins may be more resilient to the cooking process. The study also concluded that boiling cowpeas results in a significant decrease in phytic acid content, indicating a potential reduction in antinutrient levels. However, no significant difference was found in tannin content between boiled and uncooked cowpeas. It was also concluded that boiling positively influences the taste and texture attributes of cowpeas.

RECOMMENDATIONS

The following recommendations were made based on the study findings:

1. Boiling is an effective method to improve the nutrient quality and decrease anti-nutritional factors of cowpeas. Therefore, it is recommended to include boiling as a processing method for cowpeas to improve their nutritional value.
2. The boiling time and temperature should be carefully controlled to avoid excessive loss of nutrients and ensure optimum nutrient retention. Based on our study, a boiling time of 60 minutes at 100°C is recommended for cowpeas.
3. Cowpeas can be a good source of protein, minerals, and other nutrients, and can be incorporated into a healthy diet to promote health and prevent malnutrition. Therefore, it is recommended to increase the consumption of cowpeas as part of a healthy and balanced diet.
4. Further studies are needed to investigate the effects of other processing methods and cooking techniques on the nutritional quality and sensory attributes of cowpeas. These studies could help identify additional processing methods that could be used to enhance the nutritional value of cowpeas.
5. There is a need for public education and awareness campaigns to promote the consumption of cowpeas as a nutritious food source. This could include initiatives to increase availability and affordability of cowpeas, as well as campaigns to raise awareness of the nutritional benefits of cowpeas.

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Conflicts of Interest

The authors declare no conflict of interest

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