

Proximate, Antioxidant, and Sensory Properties of Tidbit Snacks from Cassava Enriched with Processed Benniseeds

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Cite This: <https://dx.doi.org/10.1021/acsfoodscitech.0c00054>

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ABSTRACT: The effects of processing methods on the proximate, antioxidant, and consumer acceptability of tidbits produced from cassava and Benniseed flours were evaluated. Tidbits are snacks primarily made of cassava and cowpea, and we sought to replace the cowpea (the original crop in tidbit production) with Benniseed, due to its high level of protein and level of antioxidant activity. The Benniseeds were subjected to defatting, roasting, steaming, fermentation, and germination before being milled into flour, while tidbits from cassava and cowpea flours served as control samples. The germination of Benniseed increased the protein content of tidbit samples (~28%) compared to that of the control sample (17%), while roasting reduced its protein content (11%) compared to that of the control sample (17%). However, the roasted sample had the highest hydroxyl radical level (113%), whereas germinated samples had better superoxide (45%) scavenging activity when compared with that of the control (31% and 5%). The result of the sensory evaluation revealed that the processing of Benniseed did not improve the sensory quality of the snacks. These findings show the potential use of Benniseed in the production of an improved tidbit snack, and Benniseeds could be used as antioxidants in the management of oxidative stress-related metabolic disorders.

KEYWORDS: antioxidants, Benniseed, cassava, processing, sensory, tidbits

1. INTRODUCTION

Consumers have been advocating for healthy and nutritional foods from formulated composite flours produced through diverse processing methods, which could help in the management of oxidative stress-related chronic diseases such as cancer and cardiovascular diseases.¹ Examples of such nutritionally developed foods are tidbit snacks, which are a product of cassava enriched with legumes and have the potential to improve the protein energy intake of poor households.² Although a tidbit is a snack from cassava–cowpea composite flour,² the cowpea could be replaced with Benniseed that possessed better protein and antioxidant activities.³ Past reports revealed the popularity and high acceptability of tidbit snacks in some sub-Saharan African countries, such as in the Kasama, Kaoma, and Mansa districts of Zambia² and Congo DR² as a result of dietary diversification. Several processing methods (roasting, fermentation, germination, and steaming) for producing flours from crops have been shown to enhance the nutritional qualities (for example, chemical and sensory) and bioactivities of the resultant snacks.^{4,5}

Meanwhile, the ability of free radicals in the pathogenesis of several oxidative stress-related chronic diseases and subsequent radical scavenging or inhibition using antioxidants from plant sources to complement the natural glutathione and superoxide dismutase has been reported.⁶ Earlier studies reported strong antioxidant potentials with radical scavenging activities, ion reducers, and metal ion chelators for plant seeds such as Bambara groundnut,¹ wonderful kola,⁷ pigeon pea,⁸ and moringa oleifera.⁹ Another example of a plant material with a

novel research background is Benniseed, which has not been fully utilized in the confectionary industries to produce more nutritious and healthy snacks. Benniseed (*Sesamum indicum* L), also known as sesame seed from the family Pedaliaceae, is a popular West African short-duration crop grown throughout the year and is rich in protein (18–28%) and fat (50–57%) with a unique set of balanced essential amino acids.^{3,5,10} It is described as a nutritionally important legume due to the presence of amino acids such as methionine and tryptophan that are generally limited in other leguminous plant.¹¹ In addition, sesamin and sesamol, the natural compounds present in Benniseed, are known to have a cholesterol lowering effect in humans, to prevent high blood pressure, and to increase the vitamin E content and the level of polysterol that aid in enhancing immune responses and possible reduction of the risk of certain cancer.⁴ In the past, the seeds were typically processed for oil production while the cake was usually useful as cattle feed. However, the quality of the resultant cake can be improved through processing methods such as roasting, boiling, steaming, and fermentation⁵ and combined with cassava flour in the formulation of highly nutritional and healthy snacks.

Received: October 15, 2020

Revised: December 18, 2020

Accepted: December 31, 2020



Hence, in this study, cassava, which has been utilized in the production of bread¹² and cowpea-based snacks,¹³ was employed in the production of tidbits after fortification with Benniseed. The previous findings about tidbit snacks² involved only consumer preferences and the organoleptic acceptance of the snacks, while no or scant information about the bioactivity of the snacks through their antioxidative activities has been published. Therefore, this study aims to produce tidbit snacks from cassava–Benniseed composite flour and to examine the effect of diverse processing methods for producing Benniseed flour on the chemical, sensory, and antioxidant properties of the final product.

2. MATERIALS AND METHODS

2.1. Materials. Benniseed, cassava, and cowpea were obtained from the University of Ilorin Agricultural Research Farm, Ilorin, Nigeria, while other ingredients were purchased from Tanke, Ilorin, Kwara, Nigeria. All apparatus and chemicals used were obtained from the Food Processing laboratory of the Department of Home Economics and Food Science, University of Ilorin.

2.1.1. Production of Benniseed, Cassava, and Cowpea Flours. Benniseeds were screened and washed to remove dirt, soaked in water for 30 min, dehulled, and divided into five portions. The first portion was defatted with *n*-hexane for 3 h in a fume hood overnight to remove the remaining hexane as previously reported.¹⁴ The second portion was roasted at 200 °C for 60 min as previously reported.¹⁵ The third portion was steamed at 100 °C for 20 min. The fourth portion was fermented for 48 h at room temperature (25 ± 2 °C) as previously reported.¹⁶ The fifth portion was soaked in water for 2 h to wet the seeds for optimum sprouting, after which it was then left at room temperature (25 ± 2 °C) for 48 h. The seeds were thereafter rinsed, spread on a jute bag for germination to take place (until ~90% germination was achieved), closely monitored, frequently watered, and separated to prevent mold growth as previously reported.² After 48 h, the seeds were rinsed and the germination process was terminated at a temperature of 40 °C for 5 h. All of the processed seeds were dried in an oven at 60 °C for 3 h, milled into flour using a hammer mill, sieved through a 0.4 mm mesh size, packaged in a high-density polyethylene bag, and stored in a refrigerator at 4 °C until further use.

The freshly harvested cassava was thoroughly peeled, washed, grated, bagged, and dewatered for 30 min using a hydraulic press; the cake was removed from the bag and broken into fine granules, after which it was oven dried at 50 °C for 2 days. It was thereafter milled into flour using a hammer mill and sieved through a 0.4 mm mesh size screen. The flour was stored in a high-density polyethylene bag in a refrigerator at 4 °C until further use.¹² The cassava flour was then thoroughly mixed with the various Benniseed flours (obtained through defatting, roasting, steaming, fermentation, and germination) and labeled as TBB, TBC, TBD, TBE, and TBF, respectively.

The cowpea seeds were dehulled, pulverized in a Warring Laboratory mill blender (HGBTWTS3, Warring Laboratory, Torrington, CT), and sieved using a 0.4 mm mesh size screen to obtain fine cowpea flour. Thereafter, the cowpea flour was thoroughly mixed with cassava flour to obtain the control flour labeled as TBA.

2.1.2. Production of Tidbits. The cassava–Benniseed and cassava–cowpea (control) tidbits were produced by forming a mixture of 20% Benniseed (or cowpea) flour and 80% cassava flour.² Salt and water were added to the flour blends to form a thick paste, which was then extruded and fried using a deep fryer with the temperature held at 160 °C for 3 min to yield a product with a low moisture content. The product was packaged in a white hermetically sealed transparent polythene bag and stored at ambient temperature for further analysis.

2.2. Analysis. **2.2.1. Analysis of Functional Properties.** The water absorption capacity (WAC) and oil absorption capacity (OAC) were determined as previously described.¹⁷ Briefly, the sample (1.0 g) was weighed into a 15 mL preweighed centrifuge tube, and 10 mL of distilled water (for WAC) or soybean oil (for OAC) was added

stepwise while the mixture was being continuously stirred at room temperature for 10 min. The suspension in the tube was centrifuged at 2500g for 20 min, and the volume of the supernatant measured. The WAC or OAC was calculated as the difference between the initial volume of water or oil used and the final volume of the decanted supernatant and in percentage, taking into consideration the density of the oil.

2.2.2. Proximate Analysis of Cassava–Cowpea and Cassava–Benniseed Tidbits. The proximate composition analysis was performed using the standard methods,¹⁸ while the total carbohydrate was obtained by difference.

2.2.3. Determination of 2,2-Diphenyl-1-picrylhydrazyl (DPPH) Radical Scavenging Activity. The tidbit was grounded in a Warring Laboratory mill blender (HGBTWTS3) and dissolved in 0.1 M sodium phosphate buffer (pH 7.0) containing 1% (w/v) Triton X-100. The sample solution (200 µL) at varying concentrations (0.1–10 mg/mL) was added to a 0.1 mM methanolic solution of DPPH (4 mL) and shaken vigorously. Synthetic glutathione was used as a substitute in tidbit samples as a negative control. The reaction mixture was allowed to stand for 30 min at room temperature in the dark. The absorbance of the mixture was determined at a wavelength of 517 nm using a spectrophotometer.¹⁷

2.2.4. Superoxide Radical Scavenging Assay. The superoxide scavenging activity was determined when a tidbit ground in a Warring Laboratory mill blender (HGBTWTS3) was dissolved in 0.1 M sodium phosphate buffer (pH 7.0) containing 1% (w/v) Triton X-100. Samples (final concentration of 1 mg/mL) were each dissolved in 50 mM Tris-HCl buffer (pH 8.3) containing 1 mM EDTA. Synthetic glutathione was used as a substitute in tidbit samples as a negative control. A small portion (80 µL) of the resulting solution was transferred into a clear bottom microplate well. Subsequently, 80 µL of buffer was added to the blank well. This was followed by addition of 40 µL of 1.5 mM pyrogallol (dissolved in 10 mM HCl) to each well in the dark, and the change in the reaction rate was measured immediately at room temperature over a period of 4 min at a wavelength of 420 nm.⁶

2.2.5. Hydroxyl Radical Scavenging Assay. The hydroxyl radical scavenging assay was carried out when the samples, glutathione (used as a negative control), and 1,10-phenanthroline (3 mM) were each separately dissolved in 0.1 M sodium phosphate buffer (pH 7.4) while FeSO₄ (3 mM) and 0.01% hydrogen peroxide were each separately dissolved in distilled water. A quantity (50 µL) of the sample, GSH (equivalent to a final assay concentration of 1 mg/mL), or buffer (control) was first added to a clear, flat bottom 96-well plate followed by addition of 50 µL of 1,10-phenanthroline and 50 µL of FeSO₄. To initiate the reaction in the wells, 50 µL of a hydrogen peroxide (H₂O₂) solution was added to the mixture, which was then covered and incubated at 37 °C for 1 h while being constantly shaken. Thereafter, the absorbance of the mixtures was taken at 536 nm every 10 min for a period of 1 h. The absorbance was also determined for a blank (does not contain samples or H₂O₂).¹⁹

2.2.6. Sensory Evaluation. Tidbit snacks were prepared and served in sensory evaluation plates. The samples were evaluated for sensory parameters such as appearance, taste, crunchiness, aroma, and overall acceptability on a nine-point hedonic scale ranging from like extremely (9) to dislike extremely (1). Fifty semitrained panelists who are regular consumers of tidbits who were among the students and staff of the University of Ilorin were employed for this exercise. The panelists were instructed to sip water before and after assessing each product.

2.2.7. Statistical Analysis. Triplicate values were obtained for all of the analyses to obtain the calculated means and standard deviations. The results were subjected to analysis of variance using SPSS version 16, while means separated by the Duncan multiple-range test (DMRT) at the *p* < 0.05 level.

3. RESULTS AND DISCUSSION

3.1. Protein Contents and Functional Properties of the Composite Flours. The protein contents of the cassava–

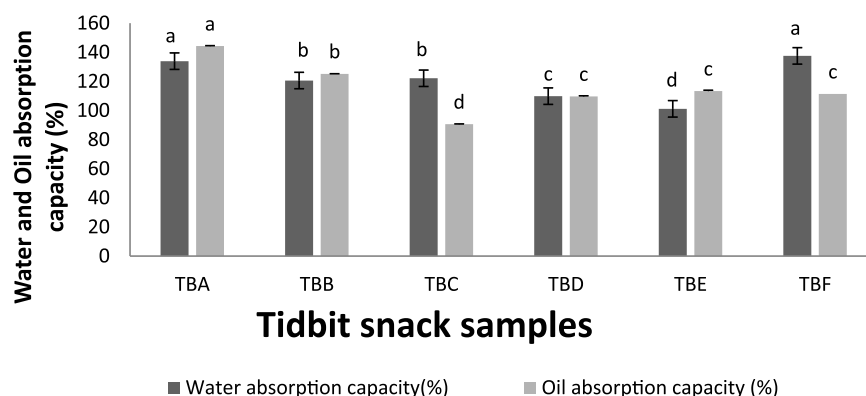


Figure 1. Water and oil absorption capacity of flour blends. Bars with different letters above them are significantly ($p < 0.05$) different. Legend: TBA, control (cassava and cowpea); TBB, cassava and defatted Bennisseed; TBC, cassava and roasted Bennisseed; TBD, cassava and steamed Bennisseed; TBE, cassava and fermented Bennisseed; TBF, cassava and germinated Bennisseed.

Table 1. Proximate Composition of Tidbit Snacks (% dry weight basis)^a

sample	moisture	ash	protein	fat	fiber	carbohydrate
TBA	3.55 ± 0.01 a	2.54 ± 0.06 bc	16.69 ± 0.06 d	41.63 ± 1.20 a	3.85 ± 0.07 a	30.43 ± 0.20 c
TBB	2.05 ± 0.02 c	2.31 ± 0.03 c	20.88 ± 0.01 c	37.49 ± 0.10 ab	2.55 ± 0.01 b	39.38 ± 1.50 b
TBC	0.25 ± 0.01 e	3.67 ± 0.08 a	11.42 ± 0.01 f	32.18 ± 1.30 c	1.75 ± 0.01 c	45.44 ± 0.10 a
TBD	2.74 ± 0.03 b	2.50 ± 0.01 bc	14.23 ± 0.01 e	33.77 ± 0.80 bc	0.90 ± 0.04 e	45.78 ± 0.90 a
TBE	1.57 ± 0.08 d	2.60 ± 0.05 bc	23.29 ± 0.23 b	34.63 ± 0.80 bc	0.88 ± 0.06 e	37.34 ± 1.70 b
TBF	2.43 ± 0.04 b	2.97 ± 0.01 b	27.87 ± 1.15 a	37.00 ± 0.60 b	1.38 ± 0.01 d	28.84 ± 1.20 c

^aMeans ± standard deviations with different letters in the same column are significantly ($p < 0.05$) different. Legend: TBA, control (cassava and cowpea); TBB, cassava and defatted Bennisseed; TBC, cassava and roasted Bennisseed; TBD, cassava and steamed Bennisseed; TBE, cassava and fermented Bennisseed; TBF, cassava and germinated Bennisseed.

based composite flours TBA, TBB, TBC, TBD, TBE, and TBF were 12.73%, 16.24%, 8.21%, 10.97%, 18.82%, and 22.24%, respectively, which fall in the range of FAO-recommended values (12–16.70%²⁰) for complementary and snack foods.

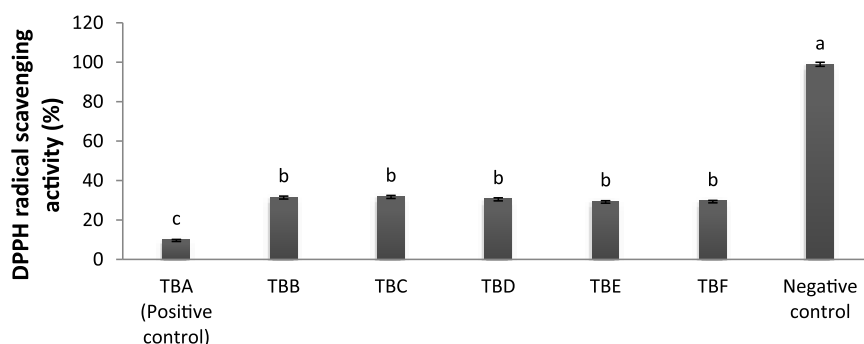
The water absorption capacity (WAC) of a food is also described as the ability of protein to prevent the loss of fluid from the food product during food storage or processing.²¹ More so, some food proteins have been known to have a high affinity for water, thereby making them appropriate for bakery production.²² The WAC values (101.15–137.52%) of the cassava–Bennisseed-enriched (TBB–TBF) and cassava–cowpea (TBA) flours are presented in Figure 1. Upon comparison of the experimental processed Bennisseed-enriched flours, germinated flour (TBF) and fermented flour (TBE) had the highest (137.52%) and lowest (101.15%) WAC values, respectively. The different methods of production for the flour samples (germination and fermentation) as well as the high protein content (22.34%) recorded for sample TBF versus a value of 18.82% for sample TBE might have contributed to the significant ($p < 0.05$) differences in their WAC values. For instance, the germination process that produced the TBF helped in the efficient reduction of sugars (growth of sprouts), thus aiding in the increase in protein content. Meanwhile, the polar amino acid residues of the resultant protein could also cause a higher affinity for water molecules, hence resulting in the increased WAC of TBF.²³

The oil absorption capacity (OAC) has been known to be a very important criterion for the development of new food products that influences their storage stability, particularly for flavor binding and in the development of rancidity.²⁴ The OAC values (90.58–144.25%) of the cassava–Bennisseed-enriched (TBB–TBF) and cassava–cowpea (TBA) flours are

presented in Figure 1. Among the experimental processed Bennisseed-enriched flours, the defatted TBB and roasted TBC samples had the highest (122%) and lowest (90.58%) OAC, respectively, when compared to the control TBA sample (cassava and cowpea). Similar high OAC values (167.67–195.00 g/mg) were also observed for cowpea–maize-produced *kokoro*.²⁴ On the contrary, low OAC values (1.04 and 1.25 g/g) were reported for roasted and raw chick pea seed flours, respectively.²⁵

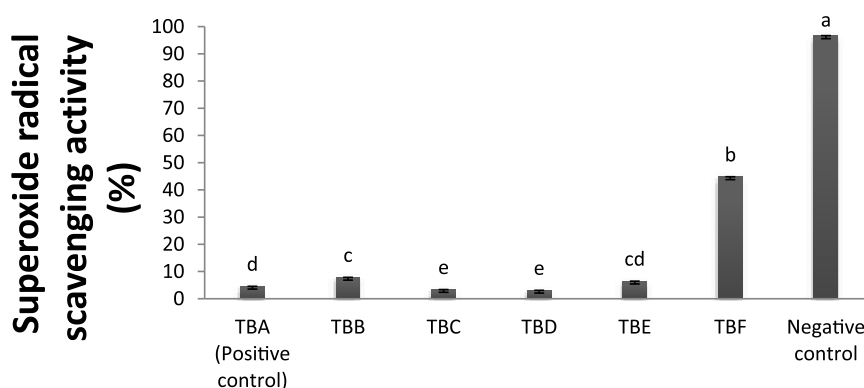
3.2. Proximate Composition of Cassava–Cowpea and Cassava–Bennisseed Tidbits. The proximate compositions of the tidbit snacks are listed in Table 1. The samples from defatted, fermented, and germinated Bennisseed (TBB, TBE, and TBF, respectively) all had protein contents of >20%, while those from roasted and steamed Bennisseed (TBC and TBD, respectively) had protein contents of <20%. The decrease in the protein content may be due to a decrease in the solubility of protein when the heat of roasting and steaming is applied to the protein source as a result of Maillard reaction, which has been implicated in protein rigidity or insolubility. A similar decreased protein solubility and the resultant reduced protein content were observed previously for green gram legumes after thermal processing.²³ However, the higher protein content of the germinated (TBF) samples (~28%), when compared with that of the control (TBA) sample (17%), may be due to the breakdown of more complex sugars and the remaining matrix of nutrients available within the structure, to expose more amino acids.²⁶ The observations presented in this study agreed with the past report²⁷ on a higher protein content for biscuits from germinated sesame seeds.

However, the current protein content (11.42–27.87%) of the tidbit snacks in this study is higher than the values of



Tidbit snack samples

Figure 2. DPPH scavenging activity of tidbit snacks. Bars with different letters above them are significantly ($p < 0.05$) different. Legend: TBA, control (cassava and cowpea); TBB, cassava and defatted Bennisseed; TBC, cassava and roasted Bennisseed; TBD, cassava and steamed Bennisseed; TBE, cassava and fermented Bennisseed; TBF, cassava and germinated Bennisseed; Negative control, synthetic glutathione.



Tidbit snack samples

Figure 3. Superoxide radical scavenging activity of tidbit snacks. Bars with different letters above them are significantly ($p < 0.05$) different. Legend: TBA, control (cassava and cowpea); TBB, cassava and defatted Bennisseed; TBC, cassava and roasted Bennisseed; TBD, cassava and steamed Bennisseed; TBE, cassava and fermented Bennisseed; TBF, cassava and germinated Bennisseed; Negative control, synthetic glutathione.

9.89%, 9.74%, and 7.6% reported for Zambian boiled and unboiled¹³ and Congo DR²⁸ soybean–cassava tidbits, respectively, which corroborated the unique and rich nutrients of Bennisseeds compared to other legumes. Interestingly, the protein content of our cassava–cowpea tidbits (16.69%) is higher than the values of 5.1% and 5.58% reported for Zambian¹³ and Congo DR²⁸ cassava–cowpea tidbits, respectively. The difference could be due to the localization (source of cultivation), species, and agronomy of the cassava and cowpea raw materials used in tidbit production.

Meanwhile, the roasted and defatted samples had the highest (3.67%) and lowest (2.31%) ash contents, respectively. All of the methods of processing the Bennisseed (such as steaming, roasting, fermentation, and germination) except defatting increased the ash content of the samples. The increase in the ash content of the fermented sample (TBE) might be due to the increase in the microbial activity causing metabolic digestion of most of the organic portions of the Bennisseed materials during the fermentation process.²⁹ Although all of the processing methods employed in the production of Bennisseed flour (except germination) decreased the fat contents of the tidbit samples, the germination process increased the remaining proximate parameters (like moisture content, fiber content, and carbohydrate content) of the tidbit samples.

3.3. DPPH Radical Scavenging Activity. DPPH is a stable free radical that showed maximum absorbance at 517 nm in methanol, which is used to evaluate the antioxidant activity of natural compounds by electron donation.⁶ The results of the DPPH radical scavenging activity (DRSA) of the Tidbit samples, which ranged from 10.09% to 31.91%, are presented in Figure 2. Interestingly, all of the samples possessed very low activity when compared with that of synthetic glutathione (negative control), which has ~100% activity. However, the DRSA of the tidbit snacks may be due to the presence of some phenol compounds (which are responsible for the antioxidant property) in the high-quality cassava flour, the major/basal flour source for the snack.³⁰ In addition, the highest and improved antioxidant (~32%) activity of the roasted Bennisseed-based sample to scavenge DPPH radicals might be a result of Maillard formation and inactivation of oil-degrading enzymes in the products. This observation somewhat agrees with the previous findings on sesame seed,¹⁵ while our result is similar to higher antioxidant values (31.8–32.7%) obtained for roasted sesame oil upon autoxidation of methyl linoleate.³¹ Notably, no significant difference was noticed in the antioxidant activities of the roasted or germinated seeds, which revealed the importance of germination in greatly improving the DRSA. In addition, control tidbits produced from cowpea and cassava (TBA) had

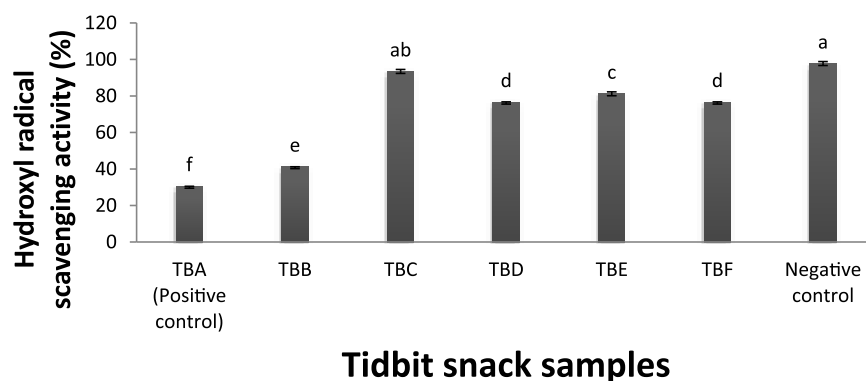


Figure 4. Hydroxyl radical scavenging activity of tidbit snacks. Bars with different letters above them are significantly ($p < 0.05$) different. Legend: TBA, control (cassava and cowpea); TBB, cassava and defatted Bennisseed; TBC, cassava and roasted Bennisseed; TBD, cassava and steamed Bennisseed; TBE, cassava and fermented Bennisseed; TBF, cassava and germinated Bennisseed; Negative control, synthetic glutathione.

Table 2. Sensory Attributes of Tidbit Snacks^a

sample	appearance	crunchiness	taste	aroma	overall acceptability
TBA	7.94 ± 0.86 a	7.96 ± 0.96 a	7.78 ± 0.06 a	7.37 ± 0.13 a	8.06 ± 0.99 a
TBB	7.63 ± 0.17 a	7.27 ± 0.13 b	7.06 ± 0.97 b	6.96 ± 0.94 ab	7.43 ± 0.84 b
TBC	7.02 ± 0.09 c	7.24 ± 0.14 b	6.78 ± 0.25 bc	7.00 ± 0.11 ab	7.14 ± 0.90 bc
TBD	7.30 ± 0.25 bc	7.30 ± 0.27 b	7.18 ± 0.22 b	7.18 ± 0.10 a	7.26 ± 0.08 b
TBE	6.96 ± 0.32 c	7.16 ± 0.22 b	6.48 ± 0.68 c	6.50 ± 0.53 b	6.72 ± 0.44 c
TBF	3.94 ± 0.56 d	5.80 ± 0.94 c	3.52 ± 0.62 d	4.12 ± 0.77 c	3.84 ± 0.66 d

^aMeans ± standard deviations with different letters in the same column are significantly ($p < 0.05$) different. Legend: TBA, control (cassava and cowpea); TBB, cassava and defatted Bennisseed; TBC, cassava and roasted Bennisseed; TBD, cassava and steamed Bennisseed; TBE, cassava and fermented Bennisseed; TBF, cassava and germinated Bennisseed.

the lowest DRSA (10%), which could be due to the higher scavenging activity of Bennisseed than of cowpea.^{15,31,32}

3.4. Superoxide Radical Scavenging Activity. The superoxide ions are generated from metabolic biological reactions such as the catalytic function of metabolic enzymes and oxidation of hemoglobin and exogenous metabolic processes in the body or food system potential,³³ thereby serving as precursors of the highly reactive hydroxyl radical.⁶ The results of the superoxide radical scavenging activity (SRSA) of the tidbit samples, which ranged from 3.36% to 44.76%, are presented in Figure 3 along with that of synthetic glutathione (negative control) that has 94.74% activity. With the exception of the germinated Bennisseed-based sample (TBF), none of the samples showed good SRSA values at 560 nm when compared with the negative control (Figure 3). The better and effective SRSA of sample TBF when compared to others could be due to the action of proteolytic enzymes, which increased the thiol proteinase content and occurrence of the oxidation process during germination.³⁴ The low SRSA (3.36%) obtained from sample TBC could be a result of the loss of polyphenol content and composition as well as the biomolecule compounds produced during roasting, which may inhibit its SRSA.³⁵

3.5. Hydroxyl Radical Scavenging Activity. Several metabolic processes from ultraviolet radiation to reactive oxygen species led to the production of free radicals like hydroxyl radicals.³⁶ The hydroxyl radical, which is generated from interaction between H_2O_2 and metal ions such as Fe^{2+} or Cu^{2+} in the Fenton reaction, is an extremely reactive and short-lived species that can damage DNA, proteins, and lipids; hence, its scavenging in the body system is crucial to provide health benefits to consumers.⁷ Hence, the ability of the tidbit snacks to act as a potent hydroxyl radical scavenger when

compared with synthetic glutathione (negative control) that has 94.22% activity is shown in Figure 4. The results ranged from 41.19% to 93.36%, with defatted (TBB) and roasted (TBC) samples having the lowest (41.19%) and highest (93.36%) activity, respectively. More so, the result (Figure 4) revealed that all of the samples possessed high hydroxyl radical scavenging activity (HRSA) except the defatted Bennisseed sample. The highest HRSA (93.36%) obtained for the roasted sample (TBC) might be due to the production of certain bioactive compounds released during roasting, which are laden with pro-scavenging abilities.³⁷

3.6. Sensory Properties of Cassava–Cowpea and Cassava–Bennisseed Tidbits. Interestingly, the sensory evaluation results presented in Table 2 revealed that the panelists generally accepted all of the samples produced from the Bennisseed-based composite flours except for the germinated sample (TBF), which was the least acceptable in terms of appearance. Notably, the control sample (TBA) had the highest acceptability, which might be due to the fact that consumers are familiar with it. However, the low acceptability of the appearance of sample TBF might be connected to a deep brown coloration developed (as opposed to the cream color of other samples) during the germination process of the Bennisseeds.²⁶ This observation is similar to the least acceptable appearance reported for biscuits produced from germinated sesame seeds.²⁷ In addition, an undesirable taste reported for the germinated samples could be as a result of the low level of some compounds responsible for the taste (such as esters and polyphenol), which might have been drastically reduced during the germination process as previously observed.²⁹

4. CONCLUSION

In conclusion, this study revealed the improvement in the proximate and antioxidant properties of tidbits through the replacement of cowpea with Benniseed during tidbit snack production. The biological activities of the organisms involved in the germination and fermentation of the Benniseeds improved the protein content of the tidbit samples when compared to those of the samples from the defatted, steamed, and roasted seeds. On the contrary, the roasted samples had the highest hydroxyl radical scavenging activities while the germinated sample had the highest superoxide radical scavenging activity. However, the tidbit snacks made from Benniseeds were less acceptable in terms of all sensory parameters compare to cowpea tidbits. Among the tidbit samples, those made from defatted and steamed Benniseeds were more acceptable. Therefore, Benniseeds can be used as an alternative to cowpeas in the production of tidbit snacks.

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Author Contributions

A.K.A.: study concept and design, writing of the draft of the paper, and data analyses. S.M.A.: writing and editing of the paper and data analyses. O.O.: writing of the paper and laboratory work. R.O.A.: writing and editing of the paper.

Notes

The authors declare no competing financial interest. This study was presented to and approved by the Ethical Committee of the Department of Home Economics and Food Science, University of Ilorin. All of the panelists were briefly screened for their ability to discern differences in the organoleptic parameters of food substances and identified themselves as regular consumers of tidbit snacks.

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