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Research Article

Physicochemical Properties of Cookies Produced from Composite Wheat, Kidney Bean and Alligator Pepper Flour

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Abstract

The nutritional properties of cookies produced from composite whole wheat, kidney bean and alligator pepper flour were analyzed. Whole wheat, kidney bean and alligator pepper were obtained from a local market in Ondo State. The whole wheat, kidney bean and alligator pepper flour were processed into flour and appropriate blends were used for producing snacks. Cookies were thereafter produced from each blend. There was Sample A -100% whole wheat served as control for other samples, Sample B, 89% whole wheat, 10%kidney bean, 1% alligator pepper, sample C: 79% Whole wheat, 20% kidney bean flour, and 1% alligator pepper. While sample D is 69% whole wheat, 30% kidney bean flour and 1% alligator pepper. The proximate analysis, functional properties and mineral content of the snacks produced from composite wheat flour, kidney bean and alligator pepper were carried out using the AOAC 2016 methods, while a 20 man panelist was used to determine the most preferred in terms of taste, color, aroma and overall acceptability. Results obtained showed that protein content increases as substitution with kidney bean flour increases from 5.61% to 10.1% in sample B showing the beneficial attributes of kidney bean. The ash content gets higher as substitution increases. Fat content increased from 2.5% to 6.56% while carbohydrate decreased from 71.13% to 59.59%. Sodium ranged from 1.62mg/100g to 1.69mg/100g. The oil and water absorption capacity increases as substitution of kidney bean increases indicating good quality for making snacks. The sensory evaluation which was done by 20 panelists indicates that sample B shows that there was no significant difference observed in overall acceptability, while significant difference ($p<0.05$) was observed in consistency and aroma. It was concluded that a substitution of 10% kidney bean flour into whole wheat flour gave the cookie with the best overall acceptability.

Keywords

Cookies, Whole Wheat, Kidney Bean, Alligator Pepper, Nutritional Evaluation

1. Introduction

Cookies is a popular snack among individuals in Nigeria and in developed countries. The basic ingredient for producing cookies is the refined wheat flour, this is low in minerals and protein. The use of legumes to substitute the refined flour tends to make snacks healthy [1]. Consumption of healthy snacks tends to reduce the incidence of certain diseases. Vegetable protein could be used to enhance the nutritional value of the snack [2] One of the leguminous materials that can be used to enhance the nutritional quality of cookies is kidney bean. Inclusion of kidney beans in the diet has many benefits in controlling and preventing various metabolic diseases such

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as diabetes mellitus, coronary heart disease and Cancer. Intercropping of leguminous and creal plants has health and nutritional benefits as it enhances survival of the crops [3]. Compositing wheat flour with flours frolocally available cereals, roots and legumes crops has being encouraged since it reduces wheat importation [4] kidney bean (Phaseolus Vulgaris) is one of the most widely cultivated and consumer food legumes and is avital source of protein, B vitamins and minerals [5] In spite of its high nutritive and health benefits, raw kidney beans contains large amount of anti nutritional factors including phytic acid, tannin and saponin which can affect the absorption of protein and certain minerals [6] Traditional processing methods such as soaking, boiling, germination and fermentation have been proven to be effective in reducing or eliminating anti-nutritional factors presents in legumes [7, 8].

In recent years, there has been growing concern over the nutritional inadequacies and health implications of commercially available snack foods, which are often high in refined carbohydrates, fats, sugars, and artificial additives, but low in essential nutrients. This nutritional imbalance has been linked to the rising prevalence of non-communicable diseases such as obesity, type 2 diabetes, and cardiovascular disorders, especially among children and young adults who form the primary consumers of snack products. As such, there is an urgent need to explore healthier alternatives that do not compromise taste or consumer acceptance.

Composite flours, which blend cereals and legumes with bioactive-rich spices, have been recognized for their potential to improve the nutritional profile of snacks.[9] Whole wheat is a good source of dietary fiber and complex carbohydrates, while kidney beans offer high-quality protein, minerals, and antioxidants. Alligator pepper, though less commonly used in conventional food products, is known for its medicinal properties and bioactive compounds, which may further enhance the health benefits of the final product. Therefore, this study investigates the nutritional quality of snacks prepared from composite flours consisting of whole wheat, kidney beans, and alligator pepper.

Objectives of the Study

The main objective of this study is to evaluate the nutritional quality of snacks prepared from composite flours consisting of whole wheat, kidney beans, and alligator pepper. Specifically:

1) analyze the proximate composition (protein, fat, fiber, carbohydrate, ash, and moisture) of the snacks produced.
2) assess the mineral content (iron, zinc, calcium, etc.) of the composite snacks.
3) evaluate the sensory properties (taste, texture, aroma, appearance, and overall acceptability) of the snacks.
4) compare the nutritional and sensory characteristics of composite snacks with those made from 100% wheat flour.

2. Materials and Methods

2.1. Source of Raw Materials

Materials used for this work were whole wheat grains, red kidney beans, alligator pepper, vegetable oil, and water. The materials were obtained from local market in Ondo State. Equipment and apparatus such as oven, milling machine, mortal, rolling pin and cutter etc. were accessed from the chemistry and microbiology laboratory of Federal University of Technology. Akure, Ondo state. Chemicals used were of analytical grade.

2.2. Preparation of Whole Wheat Flour

The method described by [2] was used in the production of whole wheat flour. The whole wheat grains were cleaned from dirt by sorting out contaminants such as sands, sticks and leaves, and were later washed and oven dried at the temperature of 55 ℃. The whole wheat was later milled using attrition mill and sieved through a 2 mm mesh sieve, packaged in an air tight sealed container for subsequent use.

2.3. Preparation of Red Kidney Beans Flour

The kidney beans were processed into flour following the method described by Chaudhary and Sharma (2013). The kidney beans seeds were sorted to remove foreign material, washed and blanched in hot water at 100 ℃ for 30 min. The blanching water was drained off, the beans washed with fresh water and soaked overnight at room temperature (27 ± 2 ℃). The soaked water was drained off and the beans dehulled manually and dried at 55 ℃ in a conventional oven (model pp 22, US, Genelab, England). The dried beans were milled into flour, sieved to pass through 2mm mesh size, packaged in an airtight container for subsequent use.

2.4. Preparation of Alligator Pepper Powder

Alligator pepper seeds are removed from the pods and cleaned to eliminate any debris. The clean seeds are then oven-dried at a moderate temperature (about 50 ℃) to reduce moisture and enhance shelf life. After drying, the seeds are ground using a spice grinder into a fine powder. The powder is sieved to ensure consistency and stored in a tightly sealed container to retain its aroma and bioactive properties.

2.5. Procedure for Production of Cookies Produced from Composite Whole Wheat Flour

Whole wheat flour, red kidney beans, alligator pepper, sugar and vegetable oil were blended at different ratios using a milling machine to obtain three (3) different blends of composite flour.

Table 1. *Blending ratio of whole wheat, kidney bean and alligator pepper flour.*

Sample	W.W flour (%)	K.B. flour (%)	A.P. flour (%)
A	100	0	0
B	89	10	1
C	79	20	1
D	69	30	1

KEY
W.W: Whole Wheat
K.B: Kidney Bean
A.P: Alligator Pepper

The method described by [2] Some modifications was used to produce cookies samples shown in Table 1. The dry components were first mixed (composite wheat flour, sugar, red kidney beans, alligator pepper) then the wet components were also mixed (vegetable oil and water). The wet components were added to the dried and kneaded for about 12mins into a consistent dough. The resulting dough was rolled out and cut into uniform sizes and passed through mold to give desired shape. The shaped dough was baked in the oven for 45 mins at 180 ℃. All the enriched cookies were packaged after cooling and stored at room temperature.

Chemical analysis-The proximate analysis and functional properties of the samples were carried out using method described by [10]. Mineral contents of the samples (iron and Calcium) were determined using Atomic Absorption spectrophotometer, while Sodium and potassium were determined by flame photometry.

Sensory Evaluation The sensory attributes of the cookies were evaluated by the multiple comparison difference test as described by [11] This was done by 20 man panel comprising staff and students of departments of Home Economics Adeyemi Federal University of Education Ondo, Nigeria who are already familiar with cookies, Each panelist was asked to score each attribute on a 9 point hedonic scale where 1 represents dislike extremely and like extremely respectively. The attributes evaluated were colour, taste, flavour, texture, appearance and overall acceptability

Statistical analysis: The data generated were analysed using Analysis of Variance, Statistical Package for social science (SPSS) version 17.0 and mean were separated using Duncans multiple range test

3. Results

Table 2. *Proximate of Cookies Produced from Whole Wheat Composite Flour, Red Kidney Bean and Alligator Pepper.(m/100mg).*

Sample	Moisture	Protein	Fibre	Ash	Fat	Carbohydrate	Energy Value (Kcal/g)
A	5.39 ±0.10^{c}	5.61 ±0.58^{d}	14.05 ±0.25^{c}	1.32 ±0.02^{c}	2.50 ±0.04^{d}	71.13 ±0.99^{a}	329.46^{b}
B	8.95 ±0.17^{a}	10.15 ±0.19^{b}	14.25 ±0.25^{b}	1.73 ±0.03^{b}	5.43 ±0.10^{b}	59.50 ±0.04^{c}	327.47^{c}
C	6.96 ±0.13^{b}	19. 20 ±0.36^{a}	10.59 ±0.19^{d}	1.93 ±0.04^{a}	6.56 ±0.12^{a}	54.77 ±0.22^{d}	285.8^{d}
D	5.04 ±0.09^{d}	8.40 ±0.16^{c}	15.17 ±0.27^{a}	1.01 ±0.02^{d}	3.93 ±0.07^{c}	66.45 ±0.07^{b}	334.77^{a}

Values are means of triplicates samples. Values followed by different alphabets along the same column are significantly different at $p<0.05$
Key:
Sample A: Whole wheat flour-100%, Sample B: whole wheat flour 89%, kidney bean flour 10%, alligator pepper 1%, Sample C: Whole wheat flour 79%, kidney bean flour 20%, alligator pepper 1%, Sample D: whole wheat flour 69%, kidney bean flour 30%, alligator pepper 1%.

Table 2: The proximate composition of the cookie samples labeled A, B, C, and D varied significantly across all measured parameters. Moisture content ranged from 5.04% in sample D to 8.95% in sample B. Sample B recorded the highest moisture

value (8.95 ± 0.17%), indicating greater water retention, which may reduce shelf life, whereas sample D had the lowest (5.04 ±0.09%), suggesting better potential for storage stability. Crude protein content was highest in sample C (19.20 ± 0.36%), indicating a strong enrichment from red kidney beans, this is as a result of the high content of kidney bean (22%), this is ascertained by the finding of [12]. This was followed by sample B (10.15 ±0.19%), while sample A had the lowest protein content (5.61 ±0.58%), reflecting a lesser contribution from legume protein. Crude fiber content also showed variation, with sample D recording the highest value (15.17 ± 0.27%), likely due to higher inclusion of whole wheat bran or alligator pepper. Sample C had the lowest fiber content (10.59 ±0.19%), which may impact its digestive benefits. In terms of ash content, which indicates the total mineral content, sample C again had the highest value (1.93 ± 0.04%), suggesting a greater concentration of minerals, whereas sample D showed the lowest ash content (1.01 ±0.02%). Crude fat content was greatest in sample C (6.56 ±0.12%), potentially due to lipid-rich ingredients or formulation while sample A had the least fat content (2.50 ±0.04%). The carbohydrate content ranged widely, with sample A showing the highest level (71.13 ± 0.99%), indicating a more energy-dense formulation dominated by flour and starch. On the other hand, sample C recorded the lowest carbohydrate content (54.77 ±0.22%), which aligns with its higher protein and fat content.

Finally, energy values, expressed in kilocalories per gram (Kcal/g), ranged from 285.8 Kcal/g in sample C to 334.77 Kcal/g in sample D. Despite having lower fat and protein, sample D had the highest energy value, largely due to its relatively higher carbohydrate content. Conversely, sample C, though rich in protein and fat, had the lowest energy value due to its reduced carbohydrate contribution.

Table 3. *Mineral Composite of Cookies Production (mg/100g).*

Sample	Na	K	Fe	Ca
A	1.62 ±0.02^{c}	2.42 ±0.01^{c}	0.27 ±0.00^{b}	1.46 ±0.01^{a}
B	1.69 ±0.02^{b}	2.52 ±0.01^{b}	0.26 ±0.00^{c}	1.37 ±0.01^{c}
C	1.81 ±0.01^{a}	2.56 ±0.01^{a}	0.30 ±0.00^{a}	1.41 ±0.01^{b}
D	0.95 ±0.01^{d}	1.27 ±0.01^{d}	0.24 ±0.00^{d}	1.47 ±0.01^{a}

Values are means of triplicates samples. Values followed by different alphabets along the same column are significantly different at $p<0.05$

Key:

Sample A: Whole wheat flour-100%, Sample B: whole wheat flour 89%, kidney bean flour 10%, alligator pepper 1%, Sample C: Whole wheat flour 79%, kidney bean flour 20%, alligator pepper 1%, Sample D: whole wheat flour 69%, kidney bean flour 30%, alligator pepper 1%.

The mineral composition of the cookie samples (A, B, C, and D) varied significantly across the four minerals analyzed: sodium (Na), potassium (K), iron (Fe), and calcium (Ca). Sodium content was highest in sample C (1.81 ±0.01 mg/100kg), followed by samples B (1.69 ±0.02 mg/100kg) and A (1.62 ± 0.02 mg/100kg), while sample D recorded the lowest sodium value (0.95 ± 0.01 mg/100kg). This indicates that sample C may contribute more to sodium intake, which can affect blood pressure regulation in consumers. Similarly, potassium levels were greatest in sample C (2.56 ±0.01 mg/100kg), closely followed by sample B (2.52 ± 0.01 mg/100kg), with sample A showing a slightly lower value (2.42 ±0.01 mg/100kg). Sample D again had the lowest potassium content (1.27 ± 0.01 mg/100kg). The high potassium content in sample C suggests better potential in supporting electrolyte balance and muscle function. With respect to iron, which is essential for oxygen transport and preventing anemia, sample C exhibited the highest value (0.30 ±0.00 mg/100kg), while samples A and B had slightly lower values (0.27 ±0.00 mg/100kg and 0.26 ±0.00 mg/100kg, respectively). Sample D had the lowest iron content (0.24 ±0.00 mg/100kg), suggesting a lesser contribution to dietary iron. In contrast, calcium content was highest in sample D (1.47 ±0.01 mg/100kg) and sample A (1.46 ±0.01 mg/100kg), followed by sample C (1.41 ± 0.01 mg/100kg), while sample B showed the lowest calcium level (1.37 ±0.01 mg/100kg). This indicates that samples D and A may offer more support for bone health due to their higher calcium concentrations.

Overall, sample C had the highest concentrations of sodium, potassium, and iron, indicating it is the most mineral-dense formulation among the samples. Sample D, despite lower values for most minerals, had the highest calcium level, which may be attributed to the unique contribution of alligator pepper or the composite flour ratio. These variations highlight the impact of ingredient composition on the mineral quality of the final cookie product.

Table 4. *Functional Properties of Cookies Production.*

Sample	Bulk Density	Oil	Water	Swelling
A	0.82 ±0.02[a]	1.33 ±0.02[d]	1.43 ±0.02[d]	402.60 ±6.60[c]
B	0.70 ±0.01[d]	1.35 ±0.02[c]	1.44 ±0.02[c]	460.05 ±7.55[a]
C	0.80 ±0.01[b]	1.44 ±0.02[b]	1.50 ±0.02[b]	424.16 ±7.00[b]
D	0.75 ±0.01[c]	1.46 ±0.02[a]	2.34 ±0.04[a]	346.30 ±5.68[d]

Values are means of triplicates samples. Values followed by different alphabets along the same column are significantly different at $p<0.05$
Key:
Sample A: Whole wheat flour-100%, Sample B: whole wheat flour 89%, kidney bean flour 10%, alligator pepper 1%, Sample C: Whole wheat flour 79%, kidney bean flour 20%, alligator pepper 1%, Sample D: whole wheat flour 69%, kidney bean flour 30%, alligator pepper 1%

The functional properties of the cookie samples, identified as A, B, C, and D, revealed notable differences across all measured parameters, indicating how variations in flour composition influence physical behavior during processing and baking.

Bulk density ranged from 0.70 to 0.82 g/cm^3, with sample A having the highest value (0.82 ±0.02 g/cm^3), suggesting a more compact structure, possibly due to finer particle size or lower porosity. Sample B had the lowest bulk density (0.70 ± 0.01 g/cm^3), indicating a looser structure, which may be beneficial for improved packaging volume and consumer acceptability. In terms of oil absorption capacity, sample D recorded the highest value (1.46 ± 0.02 g/g), while sample A had the lowest (1.33 ± 0.02 g/g). High oil absorption in sample D could be attributed to a greater presence of hydrophobic proteins or fiber, which may enhance flavor retention and mouth feel. Water absorption capacity was highest in sample D (2.34 ± 0.04 g/g), followed by sample C (1.50 ± 0.02 g/g), while sample A had the lowest water absorption (1.43 ± 0.02 g/g). The high water absorption in sample D suggests the presence of more hydrophilic constituents such as soluble fiber or protein, which is beneficial in retaining moisture during baking and improving texture. Swelling capacity, which reflects the ability of flour particles to absorb water and expand, was highest in sample B (460.05 ±7.55%), followed closely by sample C (424.16 ±7.00%). Sample D recorded the lowest swelling capacity (346.30 ±5.68%), indicating a lower ability to gelatinize or expand, which might affect the cookie's volume and texture. The high swelling in sample B may be attributed to the composition of whole wheat and red kidney bean flours, which are known for high gelatinization potential.

In summary, sample D demonstrated superior water and oil absorption capacities, which may enhance moisture retention and flavor but had the lowest swelling capacity, potentially affecting cookie volume. Sample A, despite having the highest bulk density, showed the least absorption capacities, while sample B exhibited the highest swelling capacity, suggesting it may produce cookies with better texture and aeration. These functional attributes provide useful insight into the performance of the different flour blends in cookie formulation.

Table 5. *Sensory Evaluation of Cookies from whole wheat composite flour.*

Sample	Color	Consistency	Aroma	Taste	Overall Acceptability
A	6.30 ±1.63[d]	6.25 ±1.74[c]	6.15 ±1.53[d]	6.15 ±1.76[c]	7.05 ±1.00[a]
B	7.15 ±0.84[a]	7.00 ±1.12[a]	6.70 ±1.17[a]	7.10 ±1.71[a]	7.60 ±1.43[a]
C	6.80 ±0.89[b]	6.30 ±1.69[b]	6.40 ±1.59[b]	6.04 ±1.59[d]	6.55 ±1.36[b]
D	6.60 ±1.60[c]	6.10 ±1.55[d]	6.40 ±1.60[b]	6.39 ±1.74[b]	5.55 ±1.70[c]

Values are means of triplicates samples. Values followed by different alphabets along the same column are significantly different at $p<0.05$

Table 5, review the result of the sensory evaluation of cookies formation produced from whole wheat composite flour red kidney beans and alligator pepper carried out by 20 members panelist using 6 point hedonic scale.

The sensory evaluation of cookies produced from whole wheat composite flour revealed variations in color, consistency, aroma, taste, and overall acceptability among the different samples. Sample B recorded the highest ratings across most attributes, with scores of 7.15 for color, 7.00 for consistency, 6.70 for aroma, and 7.10 for taste, leading to the

highest overall acceptability value of 7.60, indicating that it was the most preferred sample among panelists. Sample A followed closely, showing moderate ratings in all attributes, with an overall acceptability of 7.05, suggesting it was also well accepted despite lower sensory attribute scores compared to Sample B.

4. Discussion

The findings in Table 2 shows that the inclusion of red kidney bean significantly increased protein content, with sample C recording the highest value (19.20%), aligning with [13] who reported enhanced protein levels in cookies enriched with legumes. Increases of protein content could be as a result of heat treatment which improves the protein quality in pulses by destruction or inactivation of heat liable antinutritional factors [9]. The fiber content across all samples was relatively high (10.59–15.17%), consistent with the results of [14] who found similar trends in cookies made from composite flours containing fiber-rich ingredients like cocoyam and soybean. Ash content, an indicator of mineral presence, was comparable to values reported by [15] in Moringa-fortified cookies, confirming the mineral contribution of the ingredients used. Although sample C had the highest protein and fat, its carbohydrate and energy values were lower, supporting the inverse relationship observed by [16] between protein enrichment and carbohydrate dilution in legume-based cookies. The moisture content (5.04–8.95%) falls within acceptable limits for baked products and supports the shelf stability reported in [13].

The mineral composition in Table 3 shows that sample C had the highest concentrations of sodium, potassium, and iron, aligning with the findings of [13] who reported increased mineral levels in cookies fortified with legumes like pigeon pea. The potassium values (1.27–2.56 mg/100kg) are consistent with those observed by [15] suggesting that whole wheat and red kidney beans contribute significantly to potassium enrichment. Iron content was also highest in sample C (0.30 mg/100kg), supporting [17] who linked legume incorporation to improved iron bioavailability. Although calcium levels were relatively close across all samples, the highest value in sample D (1.47 mg/100kg) confirms the mineral-enhancing potential of certain spices such as alligator pepper, as previously indicated by [14].

The results in Table 4 indicate that sample D had the highest water and oil absorption capacities, which supports findings by [14] who reported increased hydration and fat-binding properties in composite flours enriched with legumes and spices. The above results also supports findings by [18] who reported increased hydration and fat-binding properties in composite flours enriched with legumes and spices. Bulk density ranged from 0.70 to 0.82 g/cm ³ comparable to values reported by [19] suggesting good packing and textural properties. Overall, the functional characteristics observed align with those reported in literature, confirming that ingredient variation, particularly with red kidney bean and alligator pepper, significantly influences flour behavior and processing quality. [20] stated that alligator pepper has strong antimicrobial effect on the kango produced from maize kidney bean and alligator pepper

The high swelling capacity observed in sample B (460.05) is consistent with [13, 21] who found similar expansion properties in cookies containing high-fiber flours. Overall, the functional characteristics observed align with those reported in literature, confirming that ingredient variation, particularly with red kidney bean and alligator pepper, significantly influences flour behavior and processing quality.

Table 5, review the result of the sensory evaluation of cookies formation produced from whole wheat composite flour red kidney beans and alligator pepper carried out 25 members panelist using 6 point hedonic scale.

The sensory evaluation of cookies produced from whole wheat composite flour revealed variations in color, consistency, aroma, taste, and overall acceptability among the different samples. Sample B recorded the highest ratings across most attributes, with scores of 7.15 for color, 7.00 for consistency, 6.70 for aroma, and 7.10 for taste, leading to the highest overall acceptability value of 7.60, indicating that it was the most preferred sample among panelists. Sample A followed closely, showing moderate ratings in all attributes, with an overall acceptability of 7.05, suggesting it was also well accepted despite lower sensory attribute scores compared to Sample B, findings here agrees with [22] that high quality bread was produced from composite whole wheat and soybean flour blends.

Sample C was rated moderately, with values between 6.04 and 6.80 for the different attributes, and an overall acceptability score of 6.55, showing that it was acceptable but less preferred than Samples A and B. Sample D, on the other hand, recorded the lowest scores in overall acceptability (5.55) despite having similar ratings for aroma and taste to Sample C, suggesting that differences in color and consistency might have contributed to its lower acceptance.

Overall, the sensory results indicate that Sample B, which likely contained a more balanced proportion of whole wheat, red kidney beans, and alligator pepper, was the most acceptable to the panelists, while Sample D was the least preferred. This suggests that ingredient composition directly influenced consumer perception of quality, particularly in terms of color, consistency, and taste. In summary, Sample B was the most preferred in terms of sensory quality, while Sample D was the least acceptable, showing that formulation significantly influenced consumer perception of the cookies.

5. Conclusion

This work shows that substitution of whole wheat flour with kidney bean and alligator pepper increases the nutritive content of cookies made from the flour. The functional properties improved and panelists of sensory evaluation preferred the cookie produced from composite flour of whole wheat flour

and kidney bean flour.

Abbreviations

WW	Whole Wheat
K.B	Kidney Beans
A.P	Alligator Pepper

Author Contributions

Adeyanju Bridget Ebunoluwa: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Conflicts of Interest

The author declares no conflicts of interest.

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