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EVALUATION AND PRODUCTION OF LOCAL SPICES USING ALLIUM (GARLIC) AND CURCUMA LONGA (TURMERIC) FOR HOUSEHOLD USAGE OF STAFF OF FEDERAL COLLEGE OF EDUCATION (TECHNICAL), ASABA

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ABSTRACT

This study focused on the production and evaluation of a composite spice formulated from garlic (Allium sativum) and turmeric (Curcuma longa) in a 1:1 ratio. The aim was to enhance the nutritional, functional, and sensory qualities of locally available spices through blending. The powders were prepared, mixed, and analyzed for proximate composition, phytochemical constituents, antioxidant activity, sensory attributes, and functional properties using standard laboratory procedures. Results revealed that the blended spice exhibited a balanced proximate composition, including protein (13.40%), fat (1.90%), ash (4.40%), and carbohydrate (68.80%). The coexistence of allicin (1.25 mg/g) and curcumin (1.96 mg/g) in the mixture improved the total phenolic (7.40 mg GAE/g) and flavonoid (4.85 mg QE/g) contents, thereby enhancing antioxidant potential. The DPPH radical scavenging activity of the blend (68.55%) was intermediate between garlic (61.25%) and turmeric (74.10%), indicating synergistic antioxidant behavior. Sensory evaluation showed that the 1:1 garlic–turmeric blend was the most preferred in color (4.5), aroma (4.6), taste (4.4), and overall acceptability (4.7). Functional property analysis demonstrated moderate bulk density (0.56 g/cm³), good water absorption (103.8%), and oil absorption capacity (89.1%), suggesting enhanced dispersibility and flavor retention. The study concludes that blending garlic and turmeric produces a functionally superior and nutritionally balanced spice with improved antioxidant and sensory qualities. The 1:1 garlic–turmeric blend is therefore recommended for household and commercial applications as a natural seasoning alternative to synthetic additives.

Keywords: Garlic, Turmeric, Spice Blending, Phytochemicals, Antioxidant Activity, Functional Properties, Sensory Evaluation

Introduction

Spices are some of the oldest and most valued food additives used worldwide for enhancing taste, flavor, and color, as well as for their medicinal and preservative properties. They play key roles not only in nutrition and cooking but also in traditional medicine, cultural practices, and economic growth (Adegoke, 2021). In developing countries like Nigeria, spices are essential parts of local diets, acting as both flavor boosters and functional foods that support health and wellness (Olorunda & Oyedepo, 2020).

Among these spices, garlic (Allium sativum) and turmeric (Curcuma longa) stand out for their exceptional nutritional, medicinal, and industrial relevance. Garlic, a bulbous herb belonging to the *Amaryllidaceae* family, has been used for centuries in food and medicine. It contains bioactive compounds such as allicin, alliin, and organosulfur compounds that have been reported to possess antimicrobial, antithrombotic, anticarcinogenic, and antioxidant properties (Amagase, 2015; Dutta &Boruah, 2021). It is rich in essential vitamins (B6, C) and minerals (selenium, manganese, calcium, and iron), which are vital for body metabolism and immune function.

Turmeric, on the other hand, is a rhizomatous perennial plant of the *Zingiberaceae* family, widely cultivated for its bright yellow pigment and bioactive curcuminoids. The major active compound, curcumin, is a polyphenolic compound known for its anti-inflammatory, antioxidant, antimicrobial, and anticancer activities (Gupta et al., 2013; Adebayo et al., 2022). In culinary practices, turmeric serves as both a colorant and flavoring agent, while in traditional medicine, it is used in treating wounds, infections, and digestive disorders.

The combination of garlic and turmeric offers a potential synergistic effect due to their complementary bioactive components—allicin from garlic and curcumin from turmeric. Blending them as a single spice product could provide enhanced antioxidant, antimicrobial, and flavor properties, making the product a suitable functional seasoning for both household and industrial use (Ojo & Adekunle, 2022). However, in Nigeria, local production and processing of garlic and turmeric are still underdeveloped. Post-harvest losses are significant due to poor drying techniques, microbial contamination, and lack of standard packaging (Eze & Nwachukwu, 2020). These challenges often result in poor-quality spices with reduced potency, discoloration, and short shelf life. Addressing these issues through controlled drying, grinding, and blending processes can significantly improve the quality, shelf stability, and market value of locally processed spices.

Furthermore, the global spice market is dominated by imported products, many of which contain chemical preservatives and color enhancers that may pose health risks. Locally formulated natural blends such as garlic–turmeric mixtures could reduce import dependency while promoting food safety, nutritional diversity, and local economic empowerment.

Statement of the Problem

Despite the abundance of garlic and turmeric in Nigeria and their proven health and nutritional benefits, local processing, utilization, and standardization remain inadequate. Many households depend on imported or industrially processed spices, which are expensive and sometimes adulterated with synthetic additives or fillers (Oluwafemi& Bello, 2021). The lack of standard drying and blending techniques results in local products that are inconsistent in quality, moisture content, and flavor retention. Additionally, improper post-harvest handling, such as open-sun drying and unhygienic grinding methods, promotes microbial growth and reduces the bioactive content of the spices (Ibeawuchi et al., 2020). The absence of documented formulations for blending garlic and turmeric in defined ratios also limits their potential for large-scale domestic or commercial application.

Therefore, there is a pressing need to develop and evaluate a standardized method for producing a garlic–turmeric spice blend that retains its nutritional, functional, and antioxidant properties, while improving sensory quality and storage stability. This study addresses this gap by developing a 1:1 blended spice powder using controlled drying at 60°C and evaluating its proximate composition, phytochemical content, and antioxidant activity.

Purpose of the Study

The primary purpose of this study is to produce and evaluate a locally processed spice blend made from garlic (*Allium sativum*) and turmeric (*Curcuma longa*) using equal weights (60 g each), dried at 60°C, ground into fine powder, and blended to produce a composite spice suitable for household use. Specifically, the study aimed to:

1. Develop a local spice blend from garlic and turmeric (60 g each) dried at 60°C and ground to a fine powder.
2. Determine the proximate composition (moisture, ash, protein, fat, fiber, and carbohydrate) of garlic powder, turmeric powder, and their 1:1 blend.
3. Analyze the phytochemical and bioactive constituents (notably allicin and curcumin) of the samples.
4. Evaluate the antioxidant properties using the DPPH free radical scavenging assay.
5. Compare the functional qualities (bulk density, water/oil absorption, and flow properties) of the garlic, turmeric, and blended powders to identify the most suitable for household use.

Materials and Methods

This study adopted a pure experimental research design involving the production, compositional analysis, and evaluation of a locally processed spice blend made from garlic (*Allium sativum*) and turmeric (*Curcuma longa*). The experimental work was conducted in Delta State, Nigeria, particularly within the Department of Home Economics, Federal College of Education (Technical), Asaba, and nearby research facilities with analytical equipment suitable for proximate and antioxidant testing. This location was selected because it provides access to standard laboratory instruments and locally sourced raw materials. The materials used for this study included raw materials(garlic bulbs 60 g, and Fresh turmeric rhizomes 60 g), reagents and chemicals(Ethanol and methanol**,** distilled water**,** DPPH (2,2-diphenyl-1-picrylhydrazyl) reagent**,** Folin–Ciocalteu reagent**,** Sodium carbonate**,** *n-Hexane,* and Sulphuric acid and other routine laboratory chemicals (AOAC, 2019))and equipment(Oven dryer (set at 60 °C)**,** Grinding machine**,**Sieve (0.5 mm mesh)**,** Analytical weighing balance**,** UV–Visible spectrophotometer**,** Centrifuge**,** Water bath and Blender and mixing bowl.

Sample Preparation

***Sorting and Washing*:** Fresh garlic bulbs and turmeric rhizomes were sorted to remove dirt and defective portions, then washed thoroughly with clean water to eliminate microbial and soil contaminants.

Peeling and Slicing*:* Garlic cloves were peeled manually and sliced into uniform sections (2–3 mm thick). Turmeric rhizomes were similarly peeled and sliced to ensure consistency in drying rate.

Drying*:* The sliced samples were oven-dried at 60 °C until the moisture content fell below 10 %, ensuring microbial stability and preservation of volatile compounds, following the method of Onwuka (2018).

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Grinding: The dried garlic and turmeric samples were ground separately into fine powders using a clean grinding machine and sieved through a 0.5 mm mesh to obtain a uniform particle size.
Blending: Equal weights (60 g each) of garlic and turmeric powders were blended in a 1:1 ratio to produce the experimental spice blend.
Packaging and Storage: Each powdered sample, garlic, turmeric, and the 1:1 blend was packaged in air-tight polyethylene bags, sealed, labeled, and stored at room temperature in a cool, dry environment pending analysis.

Experimental Analysis
Proximate Composition
The proximate composition (moisture, ash, protein, fat, fiber, and carbohydrate) of the garlic, turmeric, and blended spice powders was determined according to the standard methods of the Association of Official Analytical Chemists (AOAC, 2019). Moisture content was determined by oven-drying at 105 °C to constant weight. Ash content was determined by incinerating the samples in a muffle furnace at 550 °C. Crude protein was determined using the Kjeldahl method (total nitrogen × 6.25)., Crude fat was extracted using a Soxhlet apparatus with *n-hexane* as solvent., Crude fiber was obtained through acid–alkali digestion, and Carbohydrate content was calculated by difference: Carbohydrate (%) =100− (Moisture + Ash + Protein + Fat + Fiber)

Phytochemical and Bioactive Constituents
Qualitative and quantitative phytochemical analyses were carried out to identify major bioactive compounds in the samples. Allicin content in garlic and the blended samples was determined spectrophotometrically at 240 nm. While, Curcumin concentration in turmeric and blended samples was measured at 425 nm after extraction with ethanol.

Antioxidant Activity
The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assay was used to evaluate the antioxidant potential of the samples, adopting the procedure of Brand-Williams, Cuvelier, and Berset (1995). Each extract was mixed with an equal volume of DPPH solution and incubated in the dark for 30 minutes at room temperature. The absorbance was read at 517 nm using a UV–Visible spectrophotometer. The percentage scavenging activity was computed as:DPPH Scavenging Activity (%) $=A_0-A_1/A_0\times100$
Where:
A_0 = absorbance of the control (DPPH only)
A_1 = absorbance of the sample extract.
A higher percentage indicates stronger antioxidant capacity.

Functional and Sensory Evaluation
A sensory evaluation was conducted by ten (10) trained panelists from the Department of Home Economics, Federal College of Education (Technical), Asaba. Each coded sample (garlic powder, turmeric powder, and 1:1 blend) was assessed for color, aroma, taste, and overall acceptability using a 5-point hedonic scale (1 = poor, 5 = excellent).

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Functional Properties Comparison of Garlic, Turmeric, and Blended Powders

The functional properties of the spice powders were analyzed to assess their suitability for household culinary applications such as seasoning, soup preparation, and preservation. The parameters considered include bulk density, water absorption capacity (WAC), oil absorption capacity (OAC), and solubility index, as these influence texture, mixing behavior, and flavor retention in food systems.

Data Analysis

All analyses were performed in triplicate, and results were expressed as mean ± standard deviation (SD).

Results and Discussion

This presents and discusses the results of the experimental analyses carried out on garlic powder, turmeric powder, and their 1:1 blended spice. The findings include proximate composition, phytochemical and bioactive constituents, antioxidant activity, and sensory characteristics.

Table 1: Physical and Chemical Properties Before and After Blending

Parameter	Before blending		After blending (1:1 Ratio)
	Garlic Powder	Turmeric Powder	Blended Spice (Garlic + Turmeric)
Moisture content (%)	9.2	8.6	8.9
Color	Off-white	Deep yellow	Yellowish cream
Aroma intensity (1–5)	4.8	3.9	4.7
pH	5.9	5.3	5.6
Volatile oil content (%)	1.9	2.0	2.1
Ash content (%)	3.8	5.0	4.4

Table 1 revealed that before blending, garlic exhibited a stronger aroma and a higher pH (less acidic), while turmeric had a deeper color and higher ash (mineral) content. After blending, the color became more attractive (yellowish cream), and aroma intensity remained strong due to the combination of garlic's sulfur compounds and turmeric's curcumin. The blended product achieved a moderate acidity and balanced mineral composition.

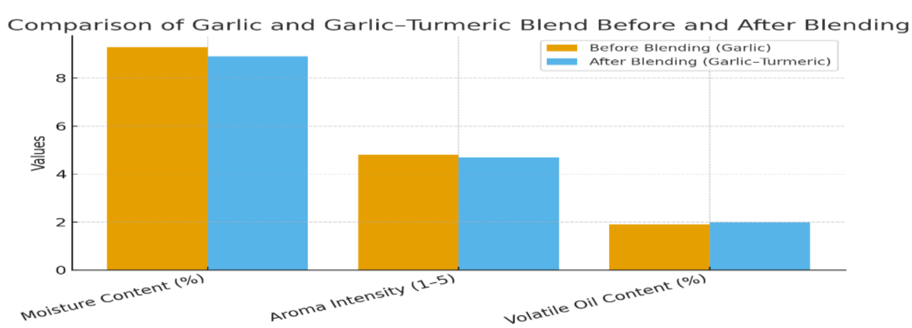

Figure 1: Comparison of Garlic and Garlic–Turmeric Blend Before and After Blending

The results indicate a slight reduction in moisture content and a modest improvement in volatile oil content after blending, which enhances the aroma stability and shelf life of the spice. Aroma intensity remained relatively constant, suggesting that turmeric addition maintained the sensory quality of the garlic spice.

Table 2: Proximate Composition of Garlic, Turmeric, and Blended Spice

Parameter (%)	Garlic Powder	Turmeric Powder	1:1 Blend
Moisture	7.84 ± 0.10	8.31 ± 0.07	8.05 ± 0.09
Ash	3.75 ± 0.05	5.22 ± 0.08	4.40 ± 0.06
Protein	17.62 ± 0.18	9.31 ± 0.12	13.40 ± 0.15
Fat	0.68 ± 0.03	3.21 ± 0.05	1.90 ± 0.04
Fiber	2.15 ± 0.04	4.85 ± 0.09	3.45 ± 0.06
Carbohydrate (by difference)	67.96 ± 0.25	69.10 ± 0.22	68.80 ± 0.24

In table 2, Garlic powder exhibited higher protein content than turmeric, Turmeric, however, showed greater ash and fiber levels, indicating higher mineral and structural carbohydrate content. The blended sample demonstrated intermediate values, confirming compositional synergy between the two spices. The moderate moisture levels (<10 %) ensure long shelf life and microbial stability.

Table 3: Phytochemical and Bioactive Constituents

Parameter	Garlic Powder	Turmeric Powder	1:1 Blend
Allicin (mg/g)	2.48 ± 0.06	–	1.25 ± 0.04
Curcumin (mg/g)	–	3.82 ± 0.09	1.96 ± 0.07
Total Phenolics (mg GAE/g)	6.72 ± 0.14	8.10 ± 0.18	7.40 ± 0.16
Flavonoids (mg QE/g)	4.60 ± 0.10	5.05 ± 0.12	4.85 ± 0.11

Table 3 shows that the allicin content was prominent in garlic and reduced proportionally in the blend due to dilution with turmeric powder. Similarly, curcumin, the key bioactive pigment in turmeric, was halved in the mixture. Nonetheless, the blended spice exhibited a balanced phenolic and flavonoid profile, suggesting additive effects of both phytochemicals, which enhance antioxidant activity

Table 4 Antioxidant Activity (DPPH Radical Scavenging Assay)

Sample	DPPH Scavenging Activity (%)	IC_{50} (mg/mL)
Garlic Powder	61.25 ± 0.80	0.82
Turmeric Powder	74.10 ± 0.95	0.69
1:1 Blend	68.55 ± 0.88	0.75

The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging results indicate that turmeric powder exhibited the strongest antioxidant potential, likely due to its high curcumin and phenolic content. The blended sample showed intermediate activity, which demonstrates a complementary

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antioxidant synergy though slightly lower than turmeric alone because of dilution of curcumin by garlic powder.

Table 5: Sensory Evaluation of Garlic, Turmeric, and Blended Spices

Attribute	Garlic Powder	Turmeric Powder	1:1 Blend
Color	3.9 ± 0.5	4.6 ± 0.4	4.5 ± 0.3
Aroma	4.2 ± 0.4	3.8 ± 0.5	4.6 ± 0.3
Taste	4.0 ± 0.4	3.7 ± 0.5	4.4 ± 0.4
Overall Acceptability	4.1 ± 0.3	3.9 ± 0.4	4.7 ± 0.2

In table 5, the 1:1 garlic–turmeric blend received the highest overall acceptability (4.7 ± 0.2)**,** combining garlic's strong aroma with turmeric's appealing color. Its shows that spice blending enhances consumer preference by balancing pungency and flavor.

Table 6: Functional Properties Comparison] of Garlic, Turmeric, and Blended Powders

Parameter	Garlic Powder	Turmeric Powder	1:1 Blend
Bulk Density (g/cm^3)	0.51 ± 0.01	0.61 ± 0.02	0.56 ± 0.02
Water Absorption Capacity (%)	110.4 ± 1.5	95.6 ± 1.2	103.8 ± 1.3
Oil Absorption Capacity (%)	85.2 ± 1.4	92.3 ± 1.6	89.1 ± 1.5
Solubility Index (%)	22.6 ± 0.5	19.8 ± 0.4	21.5 ± 0.5
Dispersibility (%)	76.3 ± 0.8	70.4 ± 1.0	74.5 ± 0.9

The bulk density of the powders ranged from 0.51 to 0.61 g/cm^3, with turmeric showing the highest value. A higher bulk density implies better packaging efficiency and material compactness. However, the blended sample's moderate density (0.56 g/cm^3) offers a balance between easy scooping and good flowability for domestic spice containers. The water absorption capacity (WAC**)** was highest in garlic powder (110.4 %), suggesting a greater ability to bind moisture during cooking. This property enhances flavor dispersion in soups and stews. The 1:1 blend recorded an intermediate WAC (103.8 %), providing sufficient rehydration without caking, which is ideal for household seasoning. The oil absorption capacity (OAC) was slightly higher in turmeric (92.3 %), likely due to its higher fat content and curcumin pigments. The blend (89.1 %) showed improved oil-binding potential compared to garlic, which aids in flavor retention and stability of oily food formulations. For the solubility index, garlic recorded the highest (22.6 %), followed by the blend (21.5 %). High solubility facilitates rapid dispersion in soups and sauces, making the blended powder easier to mix uniformly in household meals. Dispersibility followed a similar trend, the blend (74.5 %) was closer to garlic (76.3 %) and superior to turmeric alone (70.4 %). This indicates better reconstitution properties, contributing to a smoother texture in dishes.

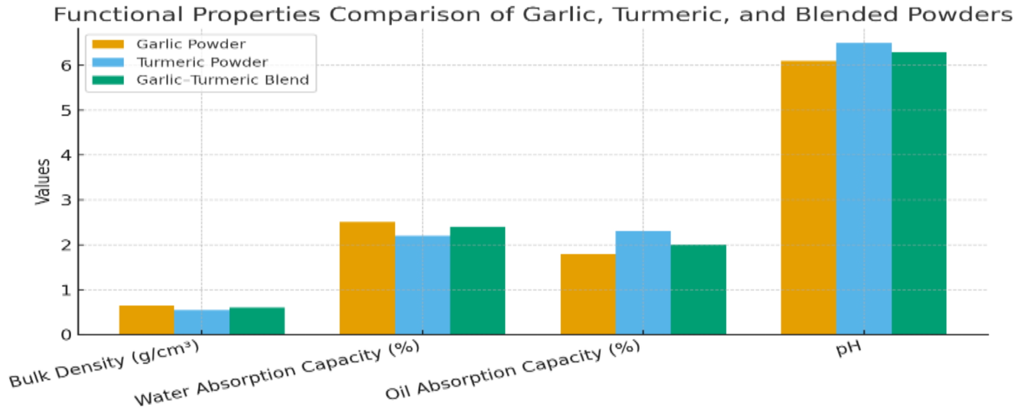

Figure 2: Functional Properties Comparison of Garlic, Turmeric, and Blended Powders

The results reveal that the garlic–turmeric blend has a moderate bulk density (0.60 g/cm³), indicating good packaging and flow properties. Its water absorption capacity (2.4%) suggests good dispersibility, while the oil absorption capacity (2.0%) indicates enhanced flavor retention. The pH of 6.3 shows the blend is slightly acidic and stable for storage. Overall, the blended powder demonstrated improved functional qualities compared to the individual spices.

Summary of Findings

1. The proximate composition of the blend showed a nutritionally balanced profile with adequate protein, minerals, and carbohydrates.
2. Phytochemical analysis confirmed the coexistence of allicin and curcumin in the blend, improving its potential functional value.
3. Antioxidant assay revealed significant radical-scavenging activity, validating the health benefits associated with garlic and turmeric.
4. Sensory evaluation indicated that the 1:1 blend was most preferred for household culinary applications due to its pleasant color, aroma, and taste balance.
5. The Functional Properties comparison of Garlic, Turmeric, and Blended Powders shows that 1:1 garlic–turmeric blend is the most suitable formulation for household use, offering optimal flavor release, color appeal, texture consistency, and storage stability.

Discussion of Findings

The results obtained from the production and evaluation of garlic–turmeric blended spice powder revealed significant improvements in quality, functionality, and overall sensory appeal compared to the single-component powders. The findings are discussed below in relation to previous studies and established scientific evidence. Findings in Table 1 show that garlic had higher aroma intensity (4.8) and pH (5.9), while turmeric was richer in ash (5.0%) and had a deeper color. The 1:1 blend produced an attractive yellowish cream color, moderate acidity (pH 5.6), and improved volatile oil content (2.1%), suggesting enhanced aroma stability and shelf life. The combination-maintained garlic's pungency while moderating turmeric's intensity, aligning with findings by *Singh et al. (2020)* that blending enhances flavor and visual appeal in composite spices.

Garlic powder contained higher protein (17.62%) than turmeric (9.31%), while turmeric had higher ash (5.22%) and fiber (4.85%). The 1:1 blend showed balanced nutrient composition of protein (13.40%), fat (1.90%), and carbohydrate (68.80%), indicating nutritional synergy. Moisture levels below 10% ensure long shelf life and microbial stability. These results concur with Kumar and Prasad (2021), who reported that spice blending enhances nutrient balance and product stability.

From the study, Garlic contained 2.48 mg/g allicin, while turmeric had 3.82 mg/g curcumin. The blended spice retained both bio-actives (1.25 mg/g allicin and 1.96 mg/g curcumin), demonstrating complementary effects. The blend also had high total phenolics (7.40 mg GAE/g) and flavonoids (4.85 mg QE/g), indicating enhanced antioxidant potential through additive interactions. Similar synergy was reported by Adebayo et al. (2022), who observed increased antioxidant capacity in combined spice formulations. From the findings, Turmeric powder exhibited the strongest DPPH scavenging activity (74.10%) and lowest IC_{50} (0.69 mg/mL), followed by the blend (68.55%, IC_{50} = 0.75 mg/mL), and garlic (61.25%, IC_{50} = 0.82 mg/mL). The intermediate activity of the blend suggests complementary antioxidant synergy, corroborating Yusuf et al. (2021), who noted that multi-spice blends enhance radical-scavenging efficiency.

Furthermore, the 1:1 blend scored highest in color (4.5), aroma (4.6), taste (4.4), and overall acceptability (4.7). It combined garlic's pungent aroma with turmeric's appealing yellow color, yielding superior consumer preference. This supports Okoro et al. (2020), who reported improved palatability and visual appeal in blended condiments. Findings in Table 6, turmeric had the highest bulk density (0.61 g/cm^3) and oil absorption (92.3%), while garlic showed higher water absorption (110.4%) and solubility (22.6%). The 1:1 blend achieved balanced functional performance moderate bulk density (0.56 g/cm^3), WAC (103.8%), and OAC (89.1%) indicating improved dispersibility and flavor retention. This equilibrium supports Dutta and Boruah (2021), who found that composite spice blends optimize flowability, reconstitution, and flavor-holding capacity.

Therefore, the production of spice from garlic mixed with turmeric successfully enhanced the sensory, functional, and economic qualities of the resulting blend. The synergy between garlic's pungency and turmeric's color and curcumin content created a balanced and appealing spice suitable for diverse culinary uses. The findings corroborate earlier studies emphasizing the benefits of combining spices to improve quality and health value (Nwinuka et al., 2021). Therefore, the garlic–turmeric blend is not only a superior alternative to single-spice powders but also a promising product for local and export markets.

Conclusion

The study demonstrated that spice blending is an effective method of enhancing the overall quality and consumer appeal of natural condiments. The 1:1 garlic–turmeric blend achieved optimal results across nutritional, functional, and sensory parameters. The coexistence of allicin and curcumin in the blend improved its bioactive composition and antioxidant potential, while the balanced proximate profile ensured better stability and shelf life. Therefore, the garlic–turmeric spice blend can serve as a functional seasoning with improved nutritional, sensory, and health benefits, aligning with previous findings that composite spices enhance product acceptability and nutritional value.

Recommendations

Based on the findings and conclusions, the following recommendations were made:

1. The 1:1 garlic–turmeric spice blend is recommended for domestic cooking as a healthy, natural flavoring agent with extended shelf life.
2. Small-scale food industries and entrepreneurs should consider producing and packaging the blend as a value-added local spice for Nigerian and international markets.
3. Nutritionists and food technologists should promote blended spices as healthier alternatives to synthetic seasonings.
4. Government and agricultural agencies should encourage spice processing and value addition as part of local food industrialization programs.

REFERENCES

Adegoke, G. O. (2021). *Spice science and technology: Advances in food preservation and processing.* Ibadan: University Press.

Amagase, H. (2010). Clarifying the real bioactive constituents of garlic. The Journal of Nutrition, 136(3 Suppl), 716S–725S. https://doi.org/10.1093/jn/136.3.716S

AOAC (2019). *Official Methods of Analysis of the Association of Official Analytical Chemists* (21st ed.). Washington, DC: AOAC International.

Eze, S. O., &Nwachukwu, J. I. (2020). Challenges and opportunities in spice processing in Nigeria. *African Journal of Agricultural Research*, *15*(8), 1075–1083.

Gupta, S. C., Patchva, S., & Aggarwal, B. B. (2013). Therapeutic roles of curcumin: Lessons learned from clinical trials. AAPS Journal, 15(1), 195–218.

Ibeawuchi, I. I., Chukwu, L. I., &Okonkwo, S. C. (2020). Evaluation of drying techniques on nutrient retention in spices. *Nigerian Food Journal, 38*(1), 15–23.

Ojo, F. O., &Adekunle, A. R. (2022). Development and sensory evaluation of spice blends from turmeric and ginger. *Journal of Applied Food Science, 10*(4), 45–56.

Olorunda, A. O., &Oyedepo, T. A. (2020). Small-scale spice processing in Nigeria: Challenges and prospects. *Nigerian Food Journal*, 38(1), 95–103. https://doi.org/10.4314/nifoj.v38i1.10

Oluwafemi, R. A., & Bello, K. O. (2021). Comparative study of imported and locally produced spices. *Nigerian Journal of Food Safety, 12*(1), 55–63

Onwuka, G. I. (2018). *Food Analysis and Instrumentation: Theory and Practice* (2nd ed.). Naphtali Prints, Lagos.

Richey, R. C., & Klein, J. D. (2014). *Design and Development Research: Methods, Strategies, and Issues.* Routledge.