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Nutritional Evaluation of Dried Jute Leaves (*Corchorus olitorius*) Enriched with Locust Beans (*Parkia biglobosa*) and Crayfish

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Abstract: *This study evaluated the nutritional composition, functional properties, mineral content, and sensory characteristics of dried jute leaves (Corchorus olitorius) enriched with locust beans (Parkia biglobosa) and crayfish. Four formulations were prepared as follows; Sample A (50% jute leaves + 50% locust beans), Sample B (50% jute leaves + 50% crayfish), Sample C (100% jute leaves), and Sample D (50% jute leaves + 25% locust beans + 25% crayfish). Proximate analysis showed protein content ranged from 21.73–24.63%, crude fibre 13.15–14.85%, fat 4.07–6.70%, ash 11.27–12.76%, moisture 11.47–12.19%, and carbohydrate 31.29–35.88%. Mineral composition revealed sodium (0.26–0.33%), calcium (0.67–1.17%), magnesium (0.49–0.65%), and iron (1.91–2.32%), with Sample D recording the highest mineral values. Functional properties varied significantly ($p \leq 0.05$), with oil absorption capacity ranging from 91.15–97.16%, water absorption capacity 1.12–1.27 g/g, foaming capacity 7.58–9.86%, and least gelation concentration 2.72–4.77%. Sensory evaluation using a 9-point hedonic scale showed that enrichment improved taste, flavour, colour, and overall acceptability, with Sample D rated highest (6.10–7.85) except in consistency (1.90). The findings indicate that fortifying dried jute leaves with locust beans and crayfish enhances their nutritional quality, functional potential, and consumer preference, making them a valuable resource for dietary diversification and food product development. Based on these findings, the enriched blends are recommended for use as functional ingredients in soups, sauces, and complementary foods to address protein–energy malnutrition and micro-nutrient deficiencies. Further research on amino acid profiles, vitamin retention, and mineral bio-availability is recommended to maximize their nutritional benefits.*

Keywords: Crayfish, Functional properties, Jute leaves, Locust beans, Proximate composition, Sensory evaluation

1. Introduction

Leafy vegetables are a fundamental component of diets across sub-Saharan Africa, supplying vitamins, minerals, dietary fiber, and bioactive phytochemicals that contribute to micronutrient adequacy and overall health. *Corchorus olitorius* (jute mallow, jute leaves) is widely consumed in West Africa and is particularly valued for its nutrient density and culinary use. It is recognized for its relatively high concentrations of iron, calcium, β-carotene, and phenolics compared with many other indigenous vegetables (Fasogbon et al., 2017)

According to Smith, et al., (2022), considerable variation exists in the proximate and mineral composition of *Corchorus. olitorius* depending on cultivar and soil regime, while Lawal, et al., (2023) confirmed its nutrient density across multiple Nigerian locations. Despite these advantages, the seasonal nature of jute leaves limits their availability, leading to reliance on preservation methods such as drying to extend shelf life and improve utilization (Fasogbon et al., 2017; Wang and Lee, 2023). Olapade and Omosebi (2018) observed that controlled drying methods enhanced functional properties of leafy vegetable powders. However, drying alone may not fully meet protein and mineral requirements, especially in low-income settings. Nutrient enrichment using complementary protein and mineral sources can therefore enhance its dietary value.

Locust beans *(Parkia biglobosa)*, a widely used African fermented condiment, have been recognized for their high protein content (30–40%), lipid fraction, and minerals such as calcium, iron, and potassium.Ibrahim, et al.,(2021) emphasized the improved digestibility and mineral bioavailability of fermented *Parkia biglobosa*, while Adekunle and Musa (2022) highlighted its favorable techno-functional attributes. Adewale et al. (2023) emphasized the probiotic, and antioxidant properties of fermented locust beans, which extend their role beyond basic nutrition.

Crayfish (small dried shrimps or prawns) are another inexpensive source of animal protein and minerals. Olaoye, et al. (2020) reported that crayfish inclusion improved the protein profile and sensory quality of cereal–legume blends. Similarly, Zhang, et al. (2023) found enhanced nutritional quality in complementary foods fortified with shrimp powder, while Uzo-Peters, et al. (2022) confirmed improvements in protein quality and consumer acceptability in crayfish-enriched foods. Blending dried jute leaves (*Corchorus olitorius)* powders with locust bean flour and crayfish powder therefore offers a route to produce an affordable, nutrient-dense ingredient suitable for soups and compleme2ntary foods. Kumar, et al. (2022) demonstrated that composite flours generally display improved techno-functional properties, while Nwosu, et al. (2024) observed better emulsifying and water absorption capacities in enriched vegetable blends. Onyeka, et al. (2023) further showed that enriched vegetable powders had improved sensory acceptability compared with unfortified controls.

Despite these advances, there remain important gaps. Bello et al. (2025) noted that very few studies have combined jute leaves, fermented locust beans, and crayfish in composite powders, while Masters (2024) emphasized the need for more systematic evaluation of African locust bean protein density in functional blends. Moreover, existing studies often fail to report proximate, mineral, functional, and sensory outcomes together, limiting application in product development.

This study therefore evaluated proximate composition, mineral content, functional properties, and sensory acceptability of four formulations of dried jute leave, enriched with fermented locust beans and crayfish. By combining compositional, techno-functional, and sensory data, the study aims to provide evidence for the use of these locally available ingredients in nutrient-dense food formulations and to identify the blend(s) with the best balance of nutrition and consumer acceptability for further product development.

2.0 Methodology

2.1 Sample Collection and Preparation

i. Sample Collection

Fresh jute leaves *(Corchorus olitorius)*, locust beans seeds *(Parkia biglobosa)*, and crayfish were purchased from Oje Market, Ede, Osun State, Nigeria. Each material was carefully sorted to remove extraneous matter such as stones, dirt, and broken shells (in the case of crayfish) prior to processing. Selection was based on freshness, uniform size, and freedom from visible microbial spoilage and stored under hygienic conditions until further processing, as described by Fasogbon et al. (2017).

ii. Sample Preparation

The jute leaves were washed thoroughly with potable water to remove dirt and debris, then spread thinly and dried at 50 °C in a hot-air oven until constant weight was achieved as described by Lawal et al. (2023). The dried leaves were milled using a laboratory hammer mill.The flour was packaged in airtight containers to maintain quality. Locust beans were processed according to traditional methods with modifications. Seeds were boiled for 12 hours to soften the seed coat, dehulled (outer covering removed), boiled again for 1 hour, and allowed to undergo natural fermentation for 3 days at ambient temperature (30 ± 2 °C), as described by Adewale et al. (2023). After fermentation, the seeds were washed, oven-dried at 60 °C for 24 hr, milled and sieved. The flour was stored in airtight, food-grade plastic containers until analysis.

Fresh crayfish samples were sorted, rinsed with potable water to remove adhering sand and impurities, and oven-dried at 60 °C for 6 h. The dried crayfish were ground into fine powder using a laboratory grinder and sieved (250 µm). Powder was stored in airtight food-grade plastic containers prior to use (Uzo-Peters et al., 2022).

iii. Sample Formulation

Four formulations were prepared:

Sample A: 50% dried jute leaf flour + 50% locust bean flour

Sample B: 50% dried jute leaf flour + 50% crayfish powder

Sample C: 100% dried jute leaf flour (control)

Sample D: 50% dried jute leaf flour + 25% locust bean flour + 25% crayfish powder

Formulations were mixed thoroughly using a Kenwood laboratory blender to ensure uniform distribution of ingredients. Samples were stored in sterile airtight containers under ambient conditions until further analysis.

2.2 Proximate Analysis

The proximate composition (moisture, crude protein, crude fat, crude fibre, ash, and carbohydrate) was determined using the methods of the Association of Official Analytical Chemists (AOAC, 2019). Moisture was determined by oven drying at 105 °C, protein by the Kjeldahl method (N × 6.25), fat by Soxhlet extraction using petroleum ether, ash by incineration in a muffle furnace at 550 °C, and fibre by sequential acid and alkali digestion. Carbohydrate was calculated by difference as described by Onwuka (2018).

2.3 Mineral Analysis

Minerals (sodium, calcium, magnesium, and iron) were determined after wet ashing of samples using nitric–perchloric acid mixture. Sodium and potassium were determined with a flame photometer, while calcium, magnesium, and iron were determined by Atomic Absorption Spectrophotometry (AOAC, 2019).

2.4 Functional Properties

Functional properties including loose bulk density (LBD), packed bulk density (PBD), water absorption capacity (WAC), oil absorption capacity (OAC), swelling capacity (SC), foaming capacity (FC), foaming stability (FS), least gelation concentration (LGC), emulsion capacity (EC), and emulsion stability (ES) were determined according to methods described by Onwuka (2018).

2.5 Sensory Evaluation

Sensory evaluation was conducted using a 9-point hedonic scale (1 = dislike extremely, 9 = like extremely). Thirty (30) member panelists was used to assessed the samples for taste, flavor, color, texture, consistency, and overall acceptability. Samples were coded with random three-digit numbers and served in identical containers to avoid bias (Lawless & Heymann, 2010; Iwe, 2016). Drinking water was provided for rinsing the mouth between evaluations.

2.6 Statistical Analysis

All analyses were conducted in triplicate, and results expressed as mean ± standard deviation. Data were analyzed using SPSS version 21.0 (IBM Corp., Armonk, NY, USA). One-way Analysis of Variance (ANOVA) was applied to determine significant differences among means, and separation of means was performed using Duncan's Multiple Range Test at a 95% confidence level ($p \leq 0.05$).

3.0 Results and Discussion

3.1 Proximate Composition of dried jute leaves and its blends

The proximate composition of the dried jute leaf samples enriched with locust beans and crayfish is presented in Figure 1. Protein content ranged from 21.73% in Sample C (100% jute leaves) to 24.63% in Sample D (50% jute leaves, 25% locust beans, 25% crayfish). The increase in protein content upon enrichment with locust beans and crayfish is expected since both locust beans and crayfish are concentrated sources of protein and essential amino acids (Adewale et al., 2023; Uzo-Peters et al., 2022). Similar findings were reported by Fasogbon et al. (2017), who observed higher protein levels in composition of selected traditional leafy vegetables in Nigeria. This rise is consistent with expectations because; Masters (2024) reviewed African locust bean and confirmed its protein density, while Adegbusi et al. (2023) reported similar findings for crayfish inclusion in complementary foods.

Crude fibre ranged between 13.15% and 14.85%, with the control sample (Sample C) having the highest value. The reduction in fibre upon enrichment could be attributed to the relatively lower fibre content of crayfish and locust beans compared to leafy vegetables (Lawal et al., 2023). Adequate dietary fiber is beneficial for bowel regulation, although excessively high levels may limit nutrient bio-availability.

Ash content varied from 11.27% (Sample C) to 12.76% (Sample D), reflecting increased mineral contribution from enrichment. Moisture content was low across samples (11.47-12.19%), indicating good storage stability. Carbohydrate content ranged between 31.29% and 35.88%, with the highest value recorded in the control (Sample C). These values are consistent with those reported for dried leafy vegetables and their composites in previous studies (Olapade & Omosebi, 2018). Low moisture values (11.5-12.2%) across all samples indicate effective drying and suggest good short-term storage stability (Lawal et al., 2023). Ash content increased with enrichment (11.27% - 12.76%), consistent with the observed rise in mineral concentrations.

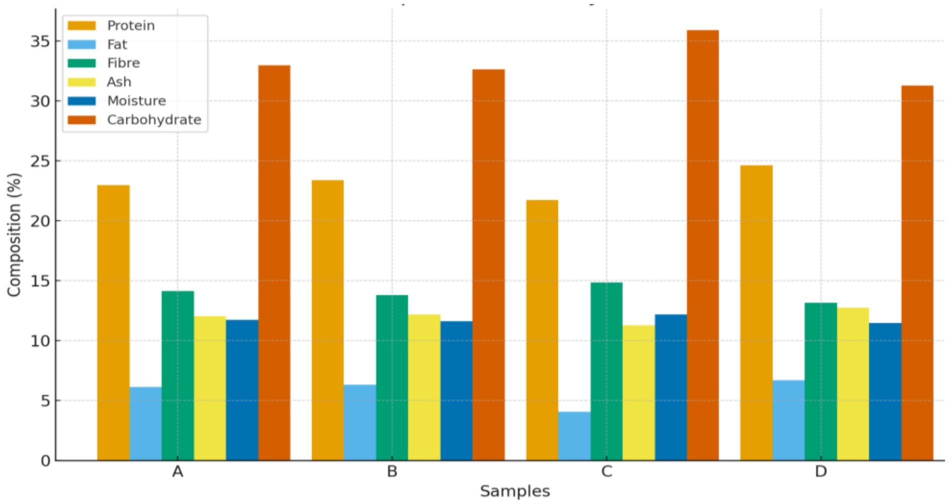

Figure 1. Proximate Composition of dried jute leaves and its blends

3.2 Mineral Composition of dried jute leaves and its blends

The mineral content of the samples is shown in Figure 2. Sodium ranged from 0.26% (Sample C) to 0.33% (Sample D), while calcium varied between 0.67% (Sample C) and 1.17% (Sample D). Magnesium ranged from 0.49% to 0.65%, and iron content was highest in Sample D (2.32%). These results confirm the role of enrichment in boosting mineral levels, particularly calcium and iron, which are critical for bone health and prevention of anemia, respectively (Hassan & Ibrahim, 2019). The higher mineral content in enriched samples may be linked to the naturally high levels of calcium and iron in crayfish and locust beans (Adewale et al., 2023; Uzo-Peters et al., 2022). Similar enhancement of mineral density was reported by Olapade and Omosebi (2018) in vegetable-legume blends.

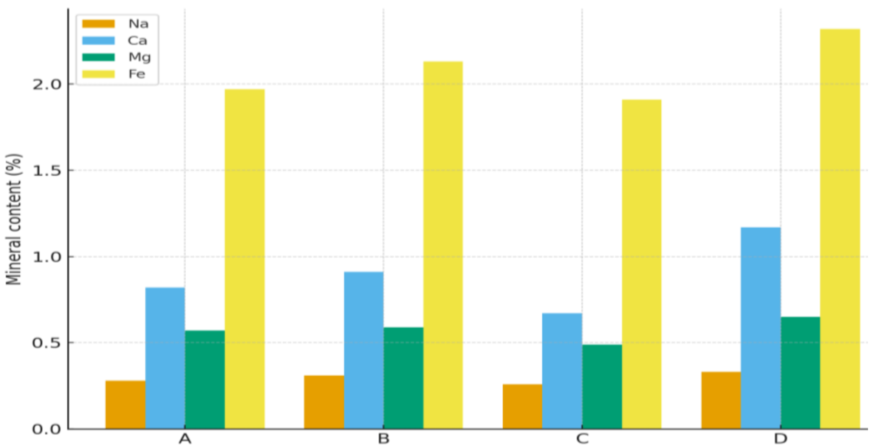

Figure 2. Mineral Composition of dried jute leaves

3.3 Functional Properties of dried jute leaves and its blends

Figure 3 presents the functional properties of dried jute leaves (*Corchorus olitorius)* enriched with locust beans and crayfish. Loose bulk density (0.53–0.69 g/cm³) and packed bulk density (0.62–0.69 g/cm³) showed slight variations among samples. The relatively high density of the control (Sample C) may be due to the fibrous nature of pure jute leaf powder, while addition of crayfish and locust beans reduced bulkiness, potentially improving mouthfeel.

Oil absorption capacity (91.15–97.16%) and water absorption capacity (1.12–1.27 g/g) were significantly affected by enrichment. Sample C exhibited the highest OAC and WAC, consistent with reports that dietary fibre enhances binding properties (Onwuka, 2018). These properties are important for food formulations such as soups and sauces where retention of flavor and water-holding capacity are desirable.

Foaming capacity (7.58–9.86%) and stability (4.24–6.78%) varied significantly ($p \leq 0.05$). Higher foaming observed in the control sample (C) may be linked to the presence of soluble proteins and saponins in jute leaves (Fasogbon et al., 2017). Enriched blends showed reduced foaming but improved emulsifying properties (EC 13.3–18.34%; ES 11.08–14.64%), which are advantageous in food systems requiring stable emulsions. Least gelation concentration ranged from 2.72% to 4.77%, with lower values in enriched samples, indicating improved gelation ability due to protein-protein interactions contributed by crayfish and locust beans (Onwuka, 2018).

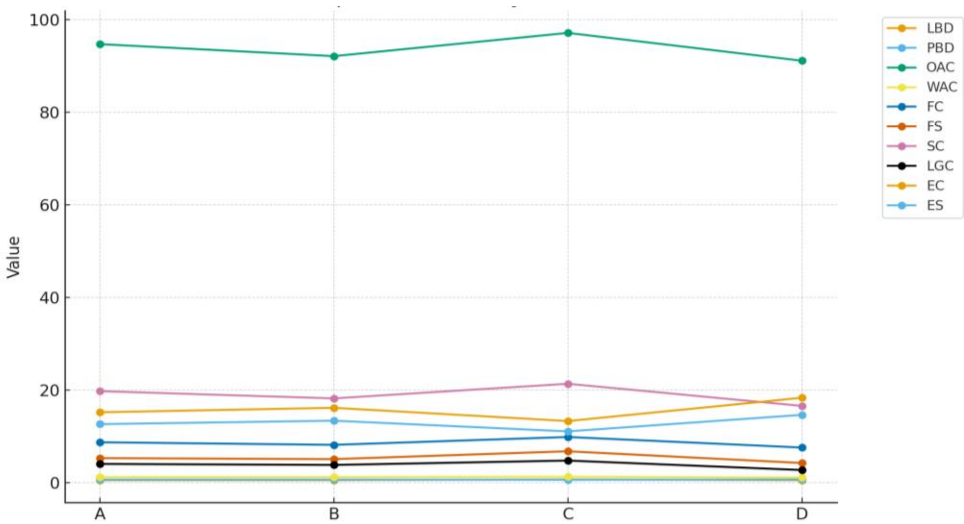

Figure 3. Functional properties of dry jute leaves enriched with locust beans and crayfish

3.4 Sensory Evaluation of dried jute leaves and its blends

Figure 4 shows sensory scores of the blends. Taste scores ranged from 3.05 (Sample C) to 7.85 (Sample D). Flavour and colour also improved significantly in enriched samples, with Sample D rated highest for both. These findings align with Uzo-Peters et al. (2022), who reported improved palatability when crayfish was incorporated into complementary foods. Texture was best rated in Sample C (7.40), probably due to the fibrous nature of pure jute leaves, but overall acceptability was highest in Sample D (7.65). Notably, consistency was poorly rated in Sample D (1.90), suggesting that higher levels of mixed condiments may compromise homogeneity. Generally, the results indicate that enrichment of jute leaves with locust beans and crayfish enhances protein, mineral, and functional qualities while improving consumer preference, making the blends suitable for dietary diversification and formulation of nutrient-dense complementary foods.

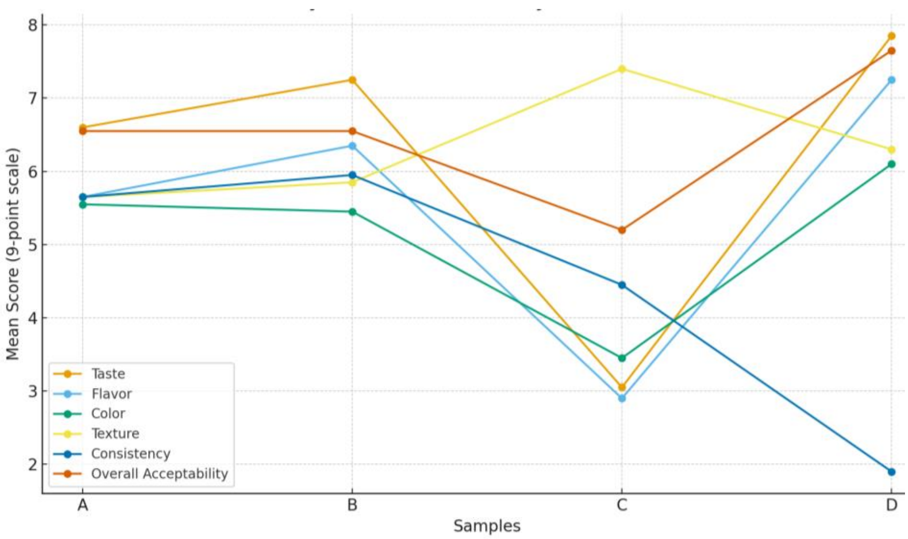

Figure 4. Sensory Evaluation of dried jute leave

4.0 Conclusion and Recommendations

4.1 Conclusion

This study demonstrated that enrichment of dried *Corchorus olitorius* (jute leaves) with *Parkia biglobosa* (locust beans) and crayfish significantly enhanced nutritional quality, mineral density, functional properties, and sensory appeal compared with 100% jute leaf flour. Proximate analysis showed notable increases in protein, fat, and ash content in enriched samples, while carbohydrate and crude fiber values decreased slightly due to substitution with protein-rich condiments. Mineral evaluation revealed marked improvements in calcium, magnesium, sodium, and iron, particularly in the composite blend containing 50% jute leaves, 25% locust beans, and 25% crayfish (Sample D). Functional properties, including emulsifying and gelation capacities, improved significantly with enrichment, suggesting wide applicability in food formulations such as soups, sauces, and instant vegetable powders. Sensory evaluation further indicated that enrichment enhanced taste, flavour, colour, and overall acceptability, though consistency was reduced in the multi-ingredient blend.

Collectively, these findings highlight the potential of leveraging locally available and culturally acceptable ingredients to produce nutrient-dense, affordable, and functional food blends. Such products could contribute to dietary diversification and help address persistent challenges of protein–energy malnutrition and micro-nutrient deficiencies (notably iron and calcium) in developing countries.

4.2 Recommendations

The study however recommends the following:

i. The enriched blends, especially the composite (Sample D), should be promoted as functional ingredients in ready-to-use soups, sauces, and convenience food formulations. Their incorporation into instant vegetable powders could enhance household nutrition while supporting small- and medium-scale processors.

ii. Formulations developed from jute leaves, locust beans, and crayfish should be considered for inclusion in school feeding programs and community nutrition initiatives, particularly for vulnerable groups such as children, pregnant women, and lactating mothers.

iii. Future studies should evaluate the amino acid profile, vitamin retention (particularly vitamin A and folates), and mineral bio-availability in enriched blends. Storage stability and shelf-life studies under varying packaging and environmental conditions are also needed to support commercialization.

iv. Nutrition policymakers and agricultural extension officers should promote the cultivation, processing, and value addition of indigenous crops such as jute leaves and locust beans, thereby linking traditional food systems to modern nutrition strategies.

v. Public education campaigns should emphasize the nutritional and economic value of locally enriched vegetable powders to improve acceptance, demand, and integration into everyday diets.

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