**ASIAN JOURNAL OF AGRICULTURE**
Volume 8, Number 2, December 2024 E-ISSN: 2580-4537
Pages: 95-103 DOI: 10.13057/asianjagric/g080203

# Nutritional evaluation of aqueous extracts of *Parquetina nigrescens* leaves for physiological manipulations of livestock feed

**ADEYINKA OYE AKINTUNDE[1,♥], LOIS CHIDINMA NDUBUISI-OGBONNA[1], OLUWAFUNMIKE OMOWUNMI OYEKALE[1], BOLATITO ADENIKE SHOBO[1], RUFUS OLUSEGUN ANIMASHAUN[2], ADERIIKE GRACE ADEWUMI[2]**

[1]Department of Agriculture and Industrial Technology, School of Science and Industrial Technology, Babcock University. Ilishan-Remo, Ogun State, Nigeria. Tel.: +234-8034784244, ♥email: adeyinka.akintunde@gmail.com

[2]Department of Basic Sciences, School of Science and Industrial Technology, Babcock University. Ilishan-Remo, Ogun State, Nigeria

Manuscript received: 3 July 2024. Revision accepted: 25 August 2024.

**Abstract.** *Akintunde AO, Ndubuisi-Ogbonna LC, Oyekale OO, Shobo BA, Animashaun RO, Adewumi AG. 2024. Nutritional evaluation of aqueous extracts of* Parquetina nigrescens *leaves for physiological manipulations of livestock feed. Asian J Agric 8: 95-103.* Plant extracts increase good bacteria's growth while reducing harmful bacteria's activity in the gastrointestinal tract. The Aqueous Extract of *Parquetina nigrescens* (Wennberg) Bullock Leaves (AEPNL) was evaluated for nutritional and phytochemical compositions. Therefore, 50 g of the leaves was blended with 1,000 mL of water and filtered. The filtrate was then analyzed for its nutritional contents. The results revealed that AEPNL contained crude protein (24.60%), crude fiber (5.60%), crude ash (3.60%), carbohydrate (62.30%), and crude fat (2.60%). AEPNL contained appreciable amounts of essential and non-essential amino acids. AEPNL contained minerals: Calcium (23.90 mg/100g), iron (3.60 mg/100g), magnesium (4.05 mg/100g), phosphorus (6.88 mg/100g), potassium (23.21 mg/100g), chlorine (0.33 mg/100g), manganese (1.46 mg/100g), sodium (0.36 mg/100g), aluminum (4.34 mg/100g), silicon (29.70 mg/100g) and titanium (2.17 mg/100g) and vitamins: A (2.30 mg/100/g) $B_1$ (275.20 mg/100g), $B_2$ (855.30 mg/100g), $B_3$ (328.20 mg/100g), C (16.20 mg/100g) and E (0.012 mg/100g). Phytochemical evaluation showed high amounts of alkaloids (8.20 mg/100g), low amounts of flavonoids, glycosides, steroids, phenols, terpenoids and anthraquinones (2.20 mg/100g, 0.06 mg/100g, 0.20 mg/100g, 0.86 mg/100g, 0.52 mg/100g and 1.55 mg/100g respectively) and moderate amounts of saponin and tannin (5.20 mg/100g and 6.30 mg/100g respectively). It can be concluded that AEPNL is of high nutritional quality with the resultant phytochemicals that could serve as supplements with huge potential in the manipulations of physiological activities of poultry and livestock species.

**Keywords:** Additives, extracts, manipulations, nutritional, *Parquetina nigrescens*, physiology, potentials

## INTRODUCTION

*Parquetina nigrescens* (Wennberg) Bullock, a plant native to West Africa, has traditionally been used for medicinal purposes. *P. nigrescens* belongs to the Perplocaceae family (Guede et al. 2010). It is a perennial shrub found in the secondary forest around villages in Senegal and Nigeria (Ayoola et al. 2011; Odukoya et al. 2018). In some Nigerian languages, *P. nigrescens* is called *ewe ogbo* (Yoruba), *kwankwanin* (Hausa), *mgbidimgbe* (Igbo), *olilia* or *ovieukpakoma* (Etsako) (Konan et al. 2013). The plant's leaves, seeds, fruits, stems, roots, and latex were commonly used in traditional medicine (Owoyele et al. 2011). The plant is a climber usually planted by rural dwellers for health benefits. The leaf is sometimes freshly crushed for its juice or as a decoction. It has been used in traditional medicine practice to treat gonorrhea, gastrointestinal disorders (GIT), menstrual disorders, wound healing, and to boost blood shortage (Imaga et al. 2010). *P. nigrescens* have been reported to be useful in the treatment of sickle cell anemia (Imaga et al. 2010) and GIT (Odetola et al. 2006).

Pharmacognostic studies of *P. nigrescens* have revealed that the plant is highly rich in protein, minerals such as magnesium and iron, vitamins such as tocopherol, ascorbic acid, some secondary metabolites, and also possesses anti-infective, analgesic, anti-inflammatory, antioxidant, and antidiabetic activities (Adebayo-Tayo et al. 2010; Sopeyin and Ajayi 2016). Akintunde et al. (2023) also concluded that *P. nigrescens* leaf extract has good antioxidant potential to improve broiler chickens' health. Ayoola et al. (2011) stated the antioxidant effects of *P. nigrescens* leaf extract were investigated in mice. The findings reveal that *P. nigrescens* contains antioxidants useful in weakening reactions that produce free radicals in the body. This discovery and the limited research focusing specifically on the possible manipulative potential of *P. nigrescens* leaves particularly aqueous extracts, on manipulating physiological status could significantly impact livestock management.

The plant contained alkaloids, cardiac glycosides, saponins, flavonoids, steroids, cardenolides, phenolics, tannins, phlobatannins, anthraquinones, and triterpenes as well as alkaloids, anthraquinones, flavonoids, and cardenolides. Furthermore, *P. nigrescens* leaves contained Na, Mg, Zn, Ca, K, Fe, Cu, Mn, P, Pb, Cd, Ni, Cr, and Co, with Fe present in the highest and Co the lowest concentrations (Kayode and Yakubu 2017; Olumide et al. 2022).

Several studies have investigated the nutritional potential of *P. nigrescens* leaf extracts in livestock production, with a lesser focus on its bioactive substances (Olaleye et al. 2021; Olumide et al. 2022; Obi and Leramo 2023; Obi and Sangosina 2024). Akinola et al. (2024) found that the administration of this extract did not significantly impact the growth parameters of Japanese quail but did affect the feed conversion ratio and final live weight, suggesting the potential for physiological manipulation. Similarly, Awoniyi et al. (2022) demonstrated the ability of the extract to overcome diet-induced iron deficiency in weaned mice, with a significant increase in hemoglobin concentration and serum protein level changes. Imaga et al. (2010) and Gbadamosi et al. (2012) highlighted the nutritional potential of *P. nigrescens*, with the former identifying a high crude protein content and the latter confirming the presence of antioxidant phytochemicals and vitamins. These findings collectively underscore the nutritional potential of *P. nigrescens* leaf extract, making it a valuable addition to livestock nutrition, particularly in iron deficiency and growth parameters.

While *P. nigrescens* has been traditionally used in ethnomedicine, its application in livestock nutrition is relatively unexplored. This study highlights the potential of AEPNL as a natural supplement to enhance livestock health and performance. The use of AEPNL could align with sustainable livestock production practices, reducing reliance on synthetic feed additives. The study explores the potentials of aqueous extracts of *P. nigrescens* leaves in modulating physiological processes in livestock, such as metabolism, growth, immune response, or reproduction. The study integrates concepts from nutrition, ethnopharmacology, and livestock physiology, offering a multidisciplinary perspective that enhances the understanding of AEPNL's potential applications thus offering its in unlocking livestock's genetic potentials.

However, this study is of significant importance despite the underutilization of *P. nigrescens* in society, especially by urban settlers (Aborisade et al. 2017). It aims to provide more detailed information on how the nutritional profile of aqueous extracts of *P. nigrescens* leaves can contribute to bringing out the genetic potential of livestock. Therefore, this study is crucial as it determines the nutritional composition of aqueous extracts *P. nigrescens* leaves and its potential for the physiological manipulation of livestock.

## MATERIALS AND METHODS

### Plant collection and sample preparation

Fresh *P. nigrescens* leaves were harvested from Ilishan-Remo, Ikenne Local Government Area in Ogun State, Nigeria. Therefore, the plant was identified and authenticated by a botanist in the Department of Basic Sciences, Babcock University, Ilishan-Remo, Ogun State, Nigeria. The fresh leaves of *P. nigrescens* were harvested around 6:00 hrs and 6:30 hrs; thereafter, they were washed. 50 g of the fresh leaves harvested were blended with 1000 mL of water using a blender. The blending was done for about 3 minutes, after which the blended samples were filtered using filter papers (Whatman paper No.1). The filtrate was then analyzed for chemical compositions. This research was conducted at the Animal Science Laboratory, Babcock University, Ilishan-Remo, Ogun State, Nigeria. Ilishan-Remo is located in Nigeria's rainforest zone, with an annual rainfall of about 1500 mm and a mean temperature of 27°C.

### Determination of proximate composition

The aqueous extract leaves of *P. nigrescens* were analyzed for proximate composition (dry matter, ash, crude fat, crude fiber, and crude protein contents) by the Association of Official Analytical Chemists (AOAC 2010) method. The gross energy content (kcal/100 g) of the extract was calculated as described in FAO (2003) and Adinortey et al. (2012), which involved multiplying the percentages of the crude protein, crude fat, and carbohydrate contents by 4.0, 9.0, and 4.0 respectively.

### Determination of amino acids profile

The amino acid profile of the aqueous leaf extracts of *P. nigrescens* was determined by the standard method described by Spackman et al. (1958). The samples were dried in an oven at 105°C for 36 hours, cooled in a desiccator, and weighed, which was repeated until a constant weight. The samples were then defatted, hydrolyzed, evaporated in a rotatory evaporator, and loaded into the Technicon Sequential Multi-Sample Amino Acid Analyzer (TSM). TSM is an automated amino acid detection, separation, and quantification tool. It operates best at temperatures between 18.3 and 35ºC (65 and 95°F) and between 10% and 80% relative humidity. Before loading into the TSM, the hydrolysate was vacuum-dried to eliminate the buffer solution. Compressed nitrogen was flown through the TSM to act as a segmented stream flow of the amino acid. This helps the analyzer detect any amino acid found and stop mix-up of amino acids. Five to ten milliliters of the sample were poured into the analyzer's cartridge. The TSM analyzer was designed to separate and analyze the hydrolysate-free acidic, neutral, and basic amino acids. The entire analysis took 76 minutes.

### Determination of minerals

Sodium and potassium contents were determined using the method described by Oshodi (1992). Phosphorus was determined by the vanadomolybdate method (AOAC 1995). The other mineral contents (elements) - calcium (Ca), sodium (Na), magnesium (Mg), potassium (K), iron (Fe), zinc (Zn), manganese (Mn), and copper (Cu) were determined using atomic absorption and flame spectrometry following Harborne (1993) and the Association of Official Analytical Chemists (AOAC 1990). Wet digestion was done by placing 10 mL of the sample in a glass tube for digestion, 12 mL of $HNO_3$ was added, and the mixture was kept overnight at room temperature. Next, 4 mL of perchloric acid was added to the mixture and digested in a fume block. The temperature was gradually increased from 50°C to 300°C, and the appearance of white fumes signaled that the digestion process was complete. After allowing the mixture to cool, the contents of the tubes were moved to 100 mL volumetric flasks. Then, distilled water was added to bring the volume of the contents to 100 mL. Labeled plastics were filled with the wet digested solution. The digest was kept and utilized to determine the minerals. The determination of iron (Fe), calcium (Ca), manganese (Mn), zinc (Zn), and magnesium (Mg) was analyzed using an atomic absorption spectrophotometer (Hitachi model 170-10). For every mineral, different electrode lamps were used. Therefore, to ensure proper operation, the equipment was run for standard solutions of each mineral both before and during the determination. All minerals except for P and Mg had a dilution factor of 100. The original solution was diluted using 0.5 mL of the original solution and distilled water to obtain a volume of up to 100 mL to determine the magnesium content. Finally, to extract Ca from Mg for the Ca determination, 1 mL of lithium oxide solution was added to the initial solution.

**Determination of vitamins contents**

Standard spectrophotometric methods of AOAC (2000) and Okwu (2004) were used in the determination of all the vitamin contents of the extracts except vitamin C, which was determined using the titrimetric method (Okwu 2004). The carotene content of AEPNL was determined by homogenizing the test sample (10 mL) in acetone solution, filtered (Whatman No. 1 filter paper), and an aqueous solution containing β-carotene was extracted from the filtrate using petroleum spirit. The absorbance of the solution was read at a wavelength of 450 nm. Vitamins B1, B2, and B3 contents were determined using the spectrophotometric method of AOAC (2005). The absorbance of vitamins B1, B2, and B3 was read at a wavelength of 360, 510, and 470 nm, respectively. Vitamin E was determined using 10 mL of AEPNL, 10 mL of absolute alcohol, and 20 mL of alcoholic tetraoxosulphate (VI) acid ($H_2SO_4$) in 100 mL flasks. 10 mL aliquots of the clear solutions were pipetted into test tubes, heated in a water bath for 30 minutes at 90°C, and cooled. The spectrophotometer was used to measure the absorbance of the solutions at 470 nm.

The vitamin C content of AEPNL was determined using 10 mL of the test sample, which was homogenized in EDTA solution and then filtered. Subsequently, the filtrate was passed through packed cotton wool containing activated charcoal to remove the color. Potassium iodide and starch (indicator) solution were added to the filtrate, and the mixture was titrated against 0.01 M $CuSO_4$ solution until an endpoint marked by black specks at the brink of the mixture was reached. The relationship gave the vitamin C content that 1 mL of 0.01 M $CuSO_4$ equals 0.88 mg of vitamin C as described by Agbai et al. (2021)

**Phytochemical analysis**

Phytochemical analysis was used to determine the presence of phytate, saponin, flavonoid, tannin, and alkaloid. Standard spectrophotometric and titrimetric methods were used to determine the phytochemical contents of the Extracts. Flavonoids were determined using the methods of Boham and Kocipai (1994), saponins, phenols, and glycosides (Obadoni and Ochuko 2002), and alkaloids by Harborne (1973). All the analyses were done using triplicate samples.

**Statistical analysis**

All analyses were conducted thrice, and the results were expressed as mean ± standard deviation. All data were analyzed using SPSS Version 21 (SPSS 2012).

## RESULTS AND DISCUSSION

Table 1 shows the proximate analysis results of the aqueous extracts of *P. nigrescens* leaves. The results revealed that *P. nigrescens* leaf extracts contained appreciable amounts of crude protein (24.60%), crude fiber (5.60%), ash (3.60%), nitrogen-free extract (62.30%) and gross energy (371.00 Kcal/100g) but a low amount of crude fat (2.60%).

Figure 1 shows the amino acid composition of the aqueous extracts of *P. nigrescens* leaves. The extracts contained appreciable amounts of the essential amino acids (histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, and valine) and non-essential amino acids (alanine, arginine, asparagine, cysteine, glutamic acid, glycine, proline, serine, and tyrosine).

Table 2 reveals the mineral and vitamin contents of the aqueous extracts of *P. nigrescens* leaves (AEPNL). AEPNL contained essential minerals: calcium (23.90 mg), iron (3.60 mg), magnesium (4.05 mg), phosphorus (6.88 mg), potassium (23.21 mg), chlorine (0.33 mg), manganese (1.46 mg), sodium (0.36 mg), aluminum (4.34 mg), silicon (29.70 mg), and titanium (2.17 mg), respectively.

The vitamin analysis reveals that AEPNL contained vitamins: vitamin A (2.30 mg/100/g) $B_1$ (275.20 mg/100g), vitamin $B_2$ (855.30 mg/100g), vitamin B3 (328.20 mg/100g), vitamin C (16.20 mg/100g) and vitamin E (0.012 mg/100g).

The aqueous extracts of *P. nigrescens* leaves contained high amounts of alkaloids (8.20 mg/100g), low amounts of flavonoids, glycosides, steroids, phenols, terpenoids, and anthraquinones (2.20 mg/100g, 0.06 mg/100g, 0.20 mg/100g, 0.86 mg/100g, 0.52 mg/100g and 1.55 mg/100g respectively) and moderate amounts of saponin and tannin (5.20 mg/100g and 6.30 mg/100g respectively) as presented in Table 3.

**Table 1.** Proximate composition of aqueous extracts of *Parquetina nigrescens* leaves

| Parameters | Concentrations |
|---|---|
| Moisture (%) | 7.80±0.20 |
| Total ash (%) | 3.60±0.20 |
| Crude protein (%) | 24.60±0.30 |
| Crude fat (%) | 2.60±0.20 |
| Crude fiber (%) | 5.60±0.20 |
| Nitrogen free extracts (%) | 62.30±0.03 |
| Gross energy (Kcal/100g) | 371.00±0.05 |

**Table 2.** Mineral and vitamin compositions of aqueous extracts of *Parquetina nigrescens* leaves

| Parameters | Conc. |
|---|---|
| Calcium (%) | 23.90±0.11 |
| Sodium (%) | 0.36±0.00 |
| Magnesium (%) | 4.05±0.01 |
| Phosphorus (%) | 6.88±0.20 |
| Potassium (%) | 23.21±0.11 |
| Chlorine (%) | 0.33±0.01 |
| Manganese (ppm) | 1.46±0.03 |
| Iron (ppm) | 3.60±0.11 |
| Aluminum (ppm) | 4.34±0.11 |
| Silicon (ppm) | 29.70±0.22 |
| Titanium (ppm) | 2.17±0.06 |
| Vitamin Content (mg/100g) | |
| Carotene (Vit. A) | 2.30±0.05 |
| Thiamin (Vit. $B_1$) | 275.20±0.12 |
| Riboflavin (Vit. $B_2$) | 855.30±0.05 |
| Niacin (Vit. $B_3$) | 328.20±0.12 |
| Ascorbic acid (Vit. C) | 16.20±2.20 |
| α-Tocopherol (Vitamin E) | 0.01±0.01 |

**Table 3.** Quantitative and qualitative phytochemical compositions of aqueous extracts of *Parquetina nigrescens* leaves

| Parameters | Conc. (mg/l00g) | Observation |
|---|---|---|
| Alkaloids | 8.20±0.05 | +++ |
| Flavonoids | 2.20±0.02 | + |
| Glycosides | 0.06±0.01 | + |
| Saponin | 5.20±0.02 | ++ |
| Steroids | 0.20±0.00 | + |
| Phenols | 0.86±0.01 | + |
| Terpenoides | 0.52±0.02 | + |
| Tannin | 6.30±0.03 | ++ |
| Antraquinones | 1.55±0.02 | + |

Note: +: Present in low amount, ++: Present in moderate amount, +++: Present in high amount

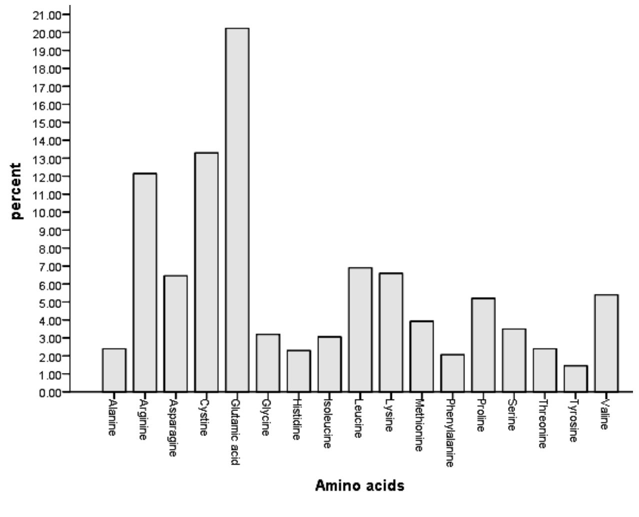


**Figure 1.** Amino acid profile of aqueous extracts of *Parquetina nigrescens* leaves

**Discussion**

The proximate analysis of AEPNL reveals relatively high amounts of crude protein, crude fiber, ash, and carbohydrates, with a low amount of crude lipid. Examining the implications of these nutritional components on monogastric animal physiology can provide insights into practical applications. Aqueous extracts of *P. nigrescens* leaf with a crude protein of 24.60% are exceptionally high compared to other plant-based feed ingredients. The crude protein content of the extract was higher than the 8.40% reported by Olumide et al. (2022); the variation could be a result of the different means of extraction and variation in the time the leaves were subjected to blending. The values obtained were also higher compared to those reported for *Ocimum gratissimum* (14.35%), *Vernonia amygdalina* (21.00%), and *Moringa oleifera* (25.90%) leaves by Olumide et al. (2019). The crude protein content was also higher compared to 21.67% of *M. oleifera* seed reported by Akintunde and Toye (2014), 14.74% for *Phyllanthus niruri* leaf (Olufayo et al. 2021), and 19.61% for *Chromolaena odorata* (Akintunde et al. 2021a). The values were, however, in proximity to the values reported for *Citrus sinensis* fruits (7.66%) (Ndubuisi-Ogbonna et al. 2021), unripe *Carica papaya* seed (8.90%) (Akintunde et al. 2021b) and 8.63% for sun-dried *C. papaya* seed (Kolu et al. 2021). Crude protein in AEPNL was also higher compared to the values reported for clove (5.87 %) and turmeric (7.04%) by Adebisi et al. (2021). This result is an indication that AEPNL has the potential to supply an adequate amount of dietary protein to animals, thus it can be used as a protein source (NRC 1994; Alagbe et al. 2020; Oluwafemi et al. 2020). The crude protein values were also higher than that of alfalfa (*Medicago sativa*), which contains about 17-20% crude protein (Broderick et al. 2000), and *C. papaya* fruit peels (Akintunde et al. 2022a). This implies that the high crude protein content of AEPNL suggests that it could serve as a superior protein source in monogastric diets, potentially reducing the need for additional protein supplements.

Aqueous extracts of *P. nigrescens* leaf contained 5.60% crude fiber, as observed in this study, implying that it has moderate fiber content. The values of crude fiber from this study were lower than the values for *M. oleifera* leaves (7-9%) (Makkar and Becker 1996), alfalfa (20-30%) (Broderick et al. 2000) and lower than 9.38% reported for PNLE as reported by Olumide et al. (2022). The fiber content of aqueous extracts of *P. nigrescens* leaf is lower than that of traditional high-fiber feeds like alfalfa but similar to *Moringa*. This suggests that AEPNL can provide adequate fiber for gut health without contributing to excessive bulk, which is beneficial for monogastric animals.

The presence of 3.60% ash reflects its mineral content but lower than the values reported for *M. oleifera* leaves (8-10%) by Makkar and Becker (1996), *P. nigrescens* extract (6.08%) by Olumide et al. (2022) but in proximity with 3.67% reported for *M. oleifera* seed meal (Akintunde and Toye 2014). This suggests that despite its low ash contents, it can still contribute to the overall mineral balance in the diet of monogastric animals. The study also showed that the aqueous extracts of *P. nigrescens* leaf also contained 32.30% nitrogen-free extracts, that is, non-fiber carbohydrates and this was in proximity with 40-45% carbohydrates for *M. oleifera* leaves (Makkar and Becker 1996), 30-35% for alfalfa (Broderick et al. 2000) but lower than 81.83% for *Pterocarpus mildbraedii* (Akintunde et al. 2022b). The carbohydrate content of AEPNL is comparable to other plant sources, providing a valuable energy source for monogastric animals.

The crude lipid of 2.60% showed that AEPNL has low lipid content. The lipid content was lower than 9.38% for *P. nigrescens* leaf extracts (Olumide et al. 2022), the unripe seed of *C. papaya* (29.50%) (Akintunde et al. 2021b), and the sun-dried and oven-dried ripe seed of *C. papaya* (27.00% and 29.50% respectively) (Kolu et al. 2021), *O. gratissimum* (4.20%), *V. amygdalina* (3.60%) and *M. oleifera* (4.60%) leaves reported by Olumide et al. (2019) but in proximity with values reported for clove (2.90%) and turmeric (1.50%) (Adebisi et al. 2021). The results, however, suggest that AEPNL cannot be used as the sole source of fat. The low lipid content is consistent with other plant-based feeds. This suggests that additional fat sources might be necessary to meet the energy needs of monogastric animals if AEPNL is to be incorporated into the feed of monogastric animals. The value obtained for gross energy was, however, in proximity with 3,700 Kcal/Kg reported for maize and 3,700 Kcal/Kg for cassava meal (Atteh 2015); higher than 3,575.70 Kcal/g and 3,011.01 Kcal/g reported for cassava peel meal and cassava leaf meal (Williams et al. 2023) thus making AEPNL an excellent energy source.

The implication in the physiological manipulations of monogastric animals if AEPNL is to be used include its potential to stimulate growth and development because of the observed relatively high crude protein. This can stimulate growth and development because the crude protein content is relatively high. The significant protein content in AEPNL can increase the rate of growth and muscle development in monogastric animals such as pigs and poultry. Sufficient protein is essential for young animals to reach their full genetic potential in growth and productivity (NRC 2012). Due to its moderate crude fiber content, it can also contribute to monogastric animals' digestive health. The fiber content supports intestinal motility and health, improving the balance of the gut microbiome. This is important to prevent digestive problems. AEPNL ensures the efficient absorption of nutrients, boosting confidence in its nutritional benefits (Jha and Berrocoso 2015). It also has the potential for mineral supplementation. The minerals in the ash content can contribute to bone development and metabolic processes, ensuring overall health and vitality (Underwood and Suttle 1999). It could also aid in energy provision. The carbohydrate content provides a readily available energy source, essential for daily activities and metabolic functions, ensuring animals maintain their energy balance (Galgani and Ravussin 2008).

The proximate analysis of AEPNL suggests that this plant could be a valuable addition to the diets of monogastric animals. Its high protein content, moderate fiber, carbohydrate levels, and essential minerals provide a balanced nutrient profile supporting growth, digestive health, and overall physiological functions. Compared to other plant-based feeds like *M. oleifera* and alfalfa, AEPNL stands out for its high protein content, making it a particularly attractive option for enhancing protein intake in monogastric animals.

The results showed that the aqueous extracts of *P. nigrescens* leaf contained both the essential and non-essential amino acids. The implications of these amino acids in the physiological manipulations in monogastric animals in the aspect of growth and muscle development is possible because of the high leucine and lysine contents; the significant amounts of leucine and lysine can enhance protein synthesis and muscle development in monogastric animals. These amino acids are crucial for maximizing growth rates and improving feed efficiency (NRC 2012). The levels of leucine (6.90%) and lysine (6.60%) are comparable to high-quality animal protein sources, making AEPNL an excellent supplement for growth and muscle development. The results showed the potential of the aqueous plant extracts in immune function and wound healing due to the high arginine content. Arginine plays a vital role in immune function and wound healing. The high arginine content (12.15%) in AEPNL can support the immune system and enhance recovery from injuries (Wu et al. 2009). The arginine content in AEPNL is significantly higher than in many plant and animal proteins, indicating its potential to boost immune function. It has potential in protein synthesis and metabolism. Methionine (3.93%) and cysteine (13.30%) are sulfur-containing amino acids crucial for protein synthesis and metabolic functions. Their presence in AEPNL supports various physiological processes, including growth and liver function (D'Mello 2003). The methionine and cystine levels in AEPNL are comparable to those in animal proteins, which are typically more bioavailable and effective in promoting growth. The high cystine content complements methionine (another sulfur-containing amino acid), which is often limiting in monogastric diets. This can enhance protein synthesis and improve growth rates (NRC 2012).

AEPNL also has high potential in energy metabolism and nervous system function. The high glutamic acid (20.23%) and asparagine (6.46%) contents are essential for energy metabolism and nervous system function. These amino acids support cognitive functions and energy production (Blachier et al. 2009). Glutamic acid levels in AEPNL are exceptionally high, which can support enhanced metabolic and neurological functions. Also, high levels of glutamic acid can support intestinal health by serving as a primary energy source for intestinal cells, enhancing nutrient absorption and overall gut function (Reeds et al. 2000). AEPNL also has the potential to improve structural integrity as glycine and proline are crucial for collagen formation, which is vital for skin, joints, and overall tissue health. Their adequate presence can improve monogastric animals' structural integrity and repair mechanisms (Wu et al. 2009). The results also showed that the aqueous extracts of *P. nigrescens* leaf could be used to optimize metabolism and cognitive functions as it contains an appreciable amount of tyrosine, which optimizing metabolism and cognitive functions as it contains an appreciable amount of tyrosine, which serves as precursors to important neurotransmitters. Tyrosine can help improve stress responses and cognitive functions, which are essential for maintaining overall animal health and productivity (Fernstrom and Fernstrom 2007). The extracts could also help enhance enzyme and membrane function as they contain an appreciable amount of serine, which plays an important role in enzyme function, and cell membrane structure supports various metabolic processes, contributing to efficient nutrient utilization and overall health (He et al. 2023). The amino acid profile of AEPNL shows a high concentration of several key amino acids, making it a valuable dietary component for monogastric animals. The comparison with other feed ingredients highlights its superior nutritional profile, particularly in cysteine and glutamic acid. These amino acids can support various physiological functions, including growth, gut health, tissue integrity, and cognitive functions. Incorporating AEPNL into monogastric animal diets can improve health, productivity, and overall well-being.

The mineral and vitamin compositions of AEPNL present a range of nutrients that can potentially benefit monogastric animals. The mineral compositions show ample calcium, magnesium, phosphorus, and potassium. These minerals are crucial for animal bone health, muscle function, and overall metabolic processes (Gupta et al. 2018). Iron is essential for oxygen transport and metabolism, particularly in hemoglobin synthesis (Baker 2009). Manganese is required for enzyme activation and skeletal development (Suttle 2010). Sodium and chlorine are important for electrolyte balance, nerve function, and osmotic regulation (Whitmore and Gunnerson 2020). Aluminum, Silicon, and Titanium, though less commonly discussed in animal nutrition, hold promising potential as anti-stress agents; their presence may affect mineral metabolism and act as potential anti-stress agents (NRC 2005). Titanium induces protein, carbohydrate, and phenolic compounds, while silicon induces amino acid levels and reduces mycotoxin contamination (Iwaniuk et al. 2022). The mineral values obtained were almost the same as those reported for *P nigrescens* leaf extract by Olumide et al. (2022), further validating our findings.

Vitamin A (carotene) is crucial for vision, growth, and immune function (Benzie and Wachtel-Galor 2011); Vitamin B1 (Thiamin), B2 (riboflavin), B3 (niacin) are essential for energy metabolism, enzyme function, and nervous system health (Combs 2012). Vitamin C (ascorbic acid) aids collagen formation, wound healing, and antioxidant defense (Jacob and Sotoudeh 2002). Vitamin E (α-Tocopherol) protects cell membranes from oxidative damage, critical for fertility and immune function (Traber and Atkinson 2007). AEPNL could contribute to physiological manipulations in monogastric animals in bone health and growth. High calcium, phosphorus, and vitamin D levels are critical for skeletal development (Gupta et al. 2018). For reproductive health, Vitamins E and A, along with minerals like selenium, influence reproductive performance and offspring viability (Surai 2002), while for immune function, Vitamins C and E, as well as trace minerals like zinc, support immune responses and disease resistance (Combs 2012). While for metabolic efficiency, B vitamins are essential for energy metabolism and nutrient utilization (Baker 2009). AEPNL contains appreciable amounts of vitamins, which make it a potentially good source of manipulating the growth and immune response of livestock, especially monogastric animals, provided all other environmental conditions are favorable and good genetic potentials of the animals.

The quantitative and qualitative phytochemical analysis of AEPNL reveals various bioactive compounds that can have significant implications for physiological manipulations in monogastric animals. Alkaloids are known for their diverse pharmacological activities, including anti-inflammatory, analgesic, and antimicrobial effects. The high alkaloid content in AEPNL aligns with other studies that report significant alkaloid presence in medicinal plants (Wink 2013). Flavonoids are potent antioxidants and play roles in anti-inflammatory and immune-modulating activities. Compared to other plant extracts, the flavonoid content in AEPNL is relatively low (Panche et al. 2016; Olumide et al. 2022). Glycosides can have cardioprotective and anti-inflammatory properties. The low glycoside content in AEPNL suggests a minimal contribution to these effects compared to other plants with higher glycoside levels (Okwu 2004; Olumide et al. 2022). Saponins have been shown to enhance nutrient absorption and possess antimicrobial properties. The moderate saponin content in AEPNL is comparable to other studies on medicinal plants (Francis et al. 2002; Olumide et al. 2022). Steroids in plants can influence hormone regulation and possess anti-inflammatory properties. The low steroid content in AEPNL is consistent with many other plant studies (Patel et al. 2009; Olumide et al. 2019, 2022). Phenolic compounds are known for their antioxidant properties. The phenol content in AEPNL is relatively low compared to other high-phenol plants (Pandey and Rizvi 2009).

Terpenoids have diverse biological activities, including antimicrobial and anti-inflammatory effects. The low terpenoid content in AEPNL is within the range reported for other medicinal plants (Mahato and Sen 1997; Olumide et al. 2022). Tannins have astringent properties and can aid in wound healing and digestion. The moderate tannin content aligns with findings in other tannin-rich plants (Hagerman 2002; Akintunde and Toye 2014; Olumide et al. 2022). Antraquinones have laxative effects and antimicrobial properties. The low anthraquinone content in AEPNL suggests limited laxative effects compared to other plants with higher anthraquinone levels (Duke 2002).

The physiological implications in monogastric animals are: high alkaloid content can enhance pain relief and reduce inflammation in monogastric animals. Alkaloids may also improve feed efficiency and growth rates due to their antimicrobial properties (Roberts and Wink 1998). Despite its low content in AEPNL, flavonoids can contribute to antioxidant defense and reduce oxidative stress in animals, improving overall health and performance (Panche et al. 2016). Glycosides, even in low amounts, can support cardiovascular health and reduce inflammation, potentially improving the resilience of monogastric animals to stressors (Okwu 2004). Moderate saponin levels can improve nutrient absorption and gut health, enhancing feed efficiency and growth performance in monogastric animals (Francis et al. 2002). Low steroid content may contribute to anti-inflammatory effects and hormonal balance, supporting animal growth and reproductive health (Patel et al. 2009). Phenolic compounds can enhance antioxidant capacity, reducing oxidative damage and improving immune function in monogastric animals (Pandey and Rizvi 2009). Though low amounts, terpenoids can provide antimicrobial benefits, enhancing disease resistance and gut health (Mahato and Sen 1997). Moderate tannin content can improve digestive health and reduce parasitic infections, supporting overall health and productivity in monogastric animals (Hagerman 2002). Low anthraquinone levels may still aid in maintaining gut health through mild laxative effects, preventing constipation, and improving nutrient absorption (Duke 2002). Moreover, AEPNL's mineral and vitamin findings further validate its antimicrobial, antioxidant, and airtight properties. However, it could be implied that the intake of AEPNL would supply the required amino acids for glutathione production and the antioxidant nutrients needed to protect the red blood cell membrane from lysis and destruction.

This study concluded that the water extract of *P. nigrescens* leaves has high nutritional quality because it contains high levels of crude protein, carbohydrates, energy, amino acids, vitamins, and minerals. The resulting phytochemical properties can be used as a feed additive in livestock production. It has great potential in manipulating the physiological activities of avian and livestock species. Its rich antioxidant and antimicrobial properties also explain its potential as an immune booster or therapeutic purpose.

## ACKNOWLEDGEMENTS

We sincerely appreciate the management of Babcock University, Ilishan-Remo, Ogun State, Nigeria, through the Office of Research, Innovation, and International Cooperation for funding this research (BURG/22/008).

## REFERENCES

Aborisade AB, Adetutu A, Owoade AO. 2017. Phytochemical and proximate analysis of some medicinal leaves. Clin Med Res 6 (6): 209-214. DOI: 10.11648/j.cmr.20170606.16.

Adebayo-Tayo BC, Adegoke AA, Okoh AI, Ajibesin KK. 2010. Rationalizing some medicinal plants used in treatment of skin diseases. Afr J Microbiol Res 10: 958-963.

Adebisi AA, Olumide MD, Akintunde AO. 2021. Nutritive value and phytochemical screening of turmeric and clove as a potential phyto-additive in livestock production. Niger J Anim Sci 23 (2): 142-152.

Adinortey MB, Sarfo JK, Quayson ET, Weremfo A, Adinortey CA, Ekloh W, Oeran J. 2012. Phytochemical screening, proximate and mineral composition of *Launaea taraxacifolia* leaves. Res J Med Plant 6 (2): 171-179. DOI: 10.3923/rjmp.2012.171.179.

Agbai CM, Olawuni IA, Ofoedu CE, Ibeabuchi CJ, Okpala COR, Shorstkii I, Korzeniowska M. 2021. Changes in anti-nutrient, phytochemical, and micronutrient contents of different processed rubber (*Hevea brasiliensis*) seed meals. PeerJ 9: e11327. DOI: 10.7717/peerj.11327.

Akinola AO, Akintunde AO, Olumide MD. 2024. Performance and physiological response of Japanese quails to administration of *Parquetina nigrescens*. Biol Sci 4 (1): 535-542. DOI: 10.55006/biolsciences.2024.4102.

Akintunde AO, Kolu P, Akintunde IA, Adewole SA, Akinboye OE, Afodu OJ, Ndubuisi-Ogbonna LC, Shobo BA. 2022a. Evaluation of the nutritive values of *Carica papaya* fruit peels as a potential ingredient in livestock nutrition. Anim Prod 24 (2): 104-113. DOI: 10.20884/1.jap.2022.24.2.129.

Akintunde AO, Kolu P, Ndubuisi-Ogbonna LC, Akinboye OE, Akintunde IA, Adewole SA. 2021b. Nutritive and phytochemical values of unripe seeds of *Carica papaya* and prospects in animal nutrition. Niger Res J Chem Sci 9 (2): 278-287.

Akintunde AO, Ndubuisi-Ogbona LC, Ajayi OA, Chioma C, Jimoh WA, Afodu OJ. 2021a. Utilization of *Chromolaena odorata* leaf meal as a supplement in broiler chickens' diet. Niger J Anim Sci 23 (1): 189-198.

Akintunde AO, Ndubuisi-Ogbonna LC, Sobowale A, Irorevbo HE, Ojo OA, Oyewumi SO, Shobo BA, Akinboye OE, Ngozi EO. 2023. Antioxidant potentials of *Parquetina nigrescens* leaf extract administration in broiler chicken production. Intl J Pharm Phytopharmacol Res 13 (5): 19-26. DOI: 10.51847/jHhpavJCEo.

Akintunde AO, Olumide MD, Ndubuisi-Ogbonna LC, Fakunle J, Maduagwu T. 2022b. Nutritive potentials of *Pterocarpus mildbraedii* in livestock production. Malays J Anim Sci 25(1): 13-21.

Akintunde AO, Toye AA 2014. Nutrigenetic effect of graded levels of *Moringa oleifera* seed meal on performance characteristics and nutrient retention in local and exotic chickens. Intl J Moringa Nutr Res 1: 56-73.

Alagbe JO, Shittu MD, Bamigboye SO, Oluwatobi AO. 2020. Proximate and mineral composition of *Pentadiplandra brazzeana* stem bark. Intl J Integr Educ 3 (11): 114-118. DOI: 10.31149/ijie.v3i11.844.

AOAC 1990. Official Methods of Analysis. 15th Edition. Association of Official Analytical Chemists, Washington DC, USA.

AOAC 1995. Official and Tentative Methods of the Association of Official Analytical Chemists International, Maryland, USA.

AOAC 2000. Association of Official Analytical Chemists. Official Methods of Analysis. 19th Edition. Washington, D.C, USA.

AOAC 2005. Official Method of Analysis. 18th Edition. Association of Analytical Chemists Internasional, Gaithersburg, Maryland, USA.

AOAC 2010. Official Methods of Analysis of Association of Official Analytical Chemists. 18th Edition. Washington, D.C, USA.

Atteh JO. 2015. Theory and Practice of Poultry Production (2nd Edition). Graphcom Publishers, Gettysburg.

Awoniyi AJ, Abidakun OM, Oladiji AT. 2022. *Parquetina nigrescens* leaf infusion: A food-based approach for the management of diet-induced iron deficiency in weanling rats. Notul Sci Biol 14 (3): 11275-11275. DOI: 10.55779/nsb14311275.

Ayoola AO, Akinloye O, Oguntibeju OO, Oke JM, Odetola AA. 2011. Antioxidant activities of *Parquetina nigrescens*. Afr J Biotechnol 10 (24): 4920-4925. DOI: 10.5897/AJB10.1622.

Baker DH. 2009. Advances in protein–amino acid nutrition of pigs and poultry. Amino Acids 37: 29-41. DOI: 10.1007/s00726-008-0198-3.

Benzie IFF, Wachtel-Galor S. 2011. Herbal Medicine: Biomolecular and Clinical Aspects (2nd Ed.). CRC Press, Boca Raton. DOI: 10.1201/b10787.

Blachier F, Boutry C, Bos C, Tome D. 2009. Metabolism and functions of L-glutamate in the epithelial cells of the small and large intestines. Am J Clin Nutr 90 (3): 814S-821S. DOI: 10.3945/ajcn.2009.27462S.

Boham AB, Kocipai AA. 1994. Flavonoids and condensed tannins from leaves of Hawaiian *Vaccinium vaticulation* and *V. calycinium*. Pac Sci 48: 458-463.

Broderick GA, Walgenbach RP, Sterrenburg E. 2000. Optimizing protein utilization in ruminants. J Dairy Sci 83 (11): 2503-2514. DOI: 10.3168/jds.S0022-0302(00)75026-0.

Combs GF. 2012. The Vitamins: Fundamental Aspects in Nutrition and Health (4th ed.). Academic Press, London.

D'Mello JF(Ed.). 2003. Amino Acids in Animal Nutrition. CABI Publishing, Wallingford. DOI: 10.1079/9780851996547.0000.

Duke JA. 2002. Handbook of Medicinal Herbs. CRC Press, Boca Raton. DOI: 10.1201/9781420040463.

FAO 2003. Food Energy—Methods of Analysis and Conversion Factors. Food and Nutrition Paper 77, Food and Agriculture Organization of the United Nations, Rome, Italy.

Fernstrom JD, Fernstrom MH. 2007. Tyrosine, phenylalanine, and catecholamine synthesis and function in the brain. J Nutr 137 (6): 1539S-1547S. DOI: 10.1093/jn/137.6.1539S.

Francis G, Kerem Z, Makkar HP, Becker K. 2002. The biological action of saponins in animal systems: A review. Br J Nutr 88 (6): 587-605. DOI: 10.1079/BJN2002725.

Galgani J, Ravussin E. 2008. Energy metabolism, fuel selection and body weight regulation. Intl J Obes 32 (7): S109-S119. DOI: 10.1038/ijo.2008.246.

Gbadamosi IT, Moody JO, Oyekini A. 2012. Nutritional composition of ten ethnobotanicals used for the treatment of anaemia in Southwest Nigeria. Eur J Med Plants 2 (2): 140-150. DOI: 10.9734/EJMP/2012/1025.

Guede NZ, N'guessan K, Dibie TE, Grellier P. 2010. Ethnopharmacological study of plants used to treat malaria, in traditional medicine, by Bete populations of Issia (Cote d"Ivoire). J Pharm Sci Res 2 (4): 216-227.

Gupta RC, Srivastava A, Lall R. 2018. Toxicity potential of nutraceuticals. In: Nicolotti O (eds). Computational Toxicology: Methods and Protocols (Methods in Molecular Biology) Springer, New York, NY, USA. DOI: 10.1007/978-1-4939-7899-1_18.

Hagerman AE. 2002. Tannin Chemistry. Miami University, Oxford.

Harborne JB. 1973. Phytochemical Methods. Chapman and Hall, London.

Harborne JB. 1993. Introduction to Ecological Biochemistry, 4th ed. Academic Press, London, United Kingdom.

He L, Ding Y, Zhou X, Li T, Yin Y. 2023. Serine signaling governs metabolic homeostasis and health. Trends Endocrinol Metabol 34 (6): 361-372. DOI: 10.1016/j.tem.2023.03.001.

Imaga NA, Gbenle GO, Okochi VI, Adenekan S, Duro-Emmanuel T, Oyeniyi B, Dokai PN, Oyenuga M, Otumara A, Ekeh FC. 2010. Phytochemical and antioxidant nutrient constituents of *Carica papaya* and *Parquetina nigrescens* extracts. Sci Res Essays 5 (16): 2201-2205.

Iwaniuk P, Kaczyński P, Pietkun M, Łozowicka B. 2022. Evaluation of titanium and silicon role in mitigation of fungicides toxicity in wheat expressed at the level of biochemical and antioxidant profile. Chemosphere 308: 136284. DOI: 10.1016/j.chemosphere.2022.136284.

Jacob RA, Sotoudeh G. 2002. Vitamin C function and status in chronic disease. Nutr Clin Care 5 (2): 66-74. DOI: 10.1046/j.1523-5408.2002.00005.x.

Jha R, Berrocoso JFD. 2015. Dietary fiber and protein fermentation in the intestine of swine and their interactive effects on gut health and on the environment: A review. Anim Feed Sci Technol 212: 18-26. DOI: 10.1016/j.anifeedsci.2015.12.002.

Kayode OT, Yakubu MT. 2017. *Parquetina nigrescens* leaves: Chemical profile and influence on the physical and biochemical indices of sexual activity of male Wistar rats. J Integr Med 15 (1): 64-76. DOI: 10.1016/S2095-4964(17)60318-2.

Kolu P, Olumide MD, Akintunde AO. 2021. Potentials of ripe *Carica papaya* seed meal using different processing methods as alternative feed ingredients in monogastric animal nutrition. Niger J Anim Sci 23 (3): 177-184.

Konan AB, Ahui ML, Saraka IA, Amonkan AK, Kouakou LK, Bléyéré MN, Datté JY. 2013. In vitro effects of hydroethanolic extract from roots bark of *Parquetina nigrescens* (Periplocaceae) on the rabbit duodenum contractile activity. World J Pharm Res 3 (1): 139-150. DOI: 10.5555/20143132701.

Mahato SB, Sen S. 1997. Advances in triterpenoid research, 1990-1994. Phytochemistry 44 (7): 1185-1236. DOI: 10.1016/s0031-9422(96)00639-5.

Makkar HPS, Becker K. 1996. Nutritional value and anti-nutritional components of whole and ethanol extracted *Moringa oleifera* leaves. Anim Feed Sci Technol 63 (1-4): 211-228. DOI: 10.1016/S0377-8401(96)01023-1.

National Research Council (NRC) 2012. Nutrient Requirements of Swine. 11th rev. ed. The National Academies Press, Washington, DC. DOI: 10.17226/13298.

National Research Council (NRC). 1994. Nutrient Requirements of Poultry: Ninth Revised Edition, 1994. The National Academies Press, Washington, DC. DOI: 10.17226/2114.

National Research Council (NRC). 2005. Mineral Tolerance of Animals: Second Revised Edition. The National Academies Press, Washington, DC. 10.17226/11309.

Ndubuisi-Ogbonna LC, Akintunde AO, Ademola AA, Akintunde IA, Afodu OJ. 2021. Evaluation of the nutritive and phytochemical properties of *Citrus sinensis* fruits as a feed ingredient in livestock production. Niger Res J Chem Sci 9 (2): 288-295.

Obadoni BO, Ochuko PO. 2002. Phytochemical studies and comparative efficacy of the crude extracts of some homeostatic plants in Edo and Delta States of Nigeria. Glob J Pure Appl Sci 8 (2): 203-208. DOI: 10.4314/gjpas.v8i2.16033.

Obi G, Leramo O. 2023. Effect of *African parquetina* aqeous extract on the haematology and serum biochemical parameters of broiler chicken. Ilaro J Sci Technol 3: 65-71.

Obi GC, Sangosina M. 2024. Carcass characteristics of broiler chicken fed *African parquetina*. Niger J Anim Prod 49: 1123-1126.

Odetola AA, Oluwole FS, Adeniyi BA, Olatiregun AM, Ikupolowo OR, Labode O, Busari KO, Shorinola JA. 2006. Antimicrobial and gastrointestinal protective properties of *Parquetina nigrescens* (Afzel.) Bullock. J Biol Sci 6 (4): 701-705. DOI: 10.3923/jbs.2006.701.705.

Odukoya JO, Odukoya JO, Oshodi AA. 2018. Evaluation of the nutritional qualities of the leaves of *Parquetina nigrescens*, *Launaea taraxacifolia* and *Solanum nigrum*. Eur J Pure Appl Chem 5 (1): 18-31. DOI: 10.9734/irjpac/2019/v18i230086.

Okwu DE. 2004. Phytochemicals and vitamin content of indigenous spices of South Eastern Nigeria. J Sustain Agric Environ 6 (1): 30-37.

Olaleye O, Oladipupo A, Oyawaluja B, Coker H. 2021. Chemical composition, antioxidative and antimicrobial activities of different extracts of the leaves of *Parquetina nigrescens* (Asclepiadaceae). Progr Chem Biochem Res 4: 359-371. DOI: 10.22034/pcbr.2021.287025.1188.

Olufayo OO, Tayo GO, Olumide MD, Akintunde AO. 2021. Assessment of the nutritive value of *Phyllanthus niruri* Linn. (Stonebreaker) leaves. Niger J Anim Sci 23 (3): 108-115.

Olumide MD, Ajayi OA, Akinboye OE. 2019. Comparative study of proximate, mineral and phytochemical analysis of the leaves of *Ocimum gratissimum, Vernonia amygdalina* and *Moringa oleifera*. J Med Plants Res 13 (15): 351-356. DOI: 10.5897/JMPR2019.6775.

Olumide MD, Akintunde AO, Ndubuisi-Ogbonna LC, Shobo BA, Oreagba T, Isiadinso I. 2022. Nutritional and ethnomedicinal potentials of *Parquetina nigrescens* leaf extracts in livestock production. Trop Anim Prod Invest 25 (1): 15-26.

Oluwafemi RA, Olawale AI, Alagbe JO. 2020. Recent trends in the utilization of medicinal plants as growth promoters in poultry nutrition- A review. Res Agric Vet Sci 4 (1): 5-11.

Oshodi AA. 1992. Comparison of proteins, minerals and vitamin c content of some dried leafy vegetables. Pak J Sci Ind Res 35 (7-8): 267-269.

Owoyele BV, Oyelowo OT, Biliaminu SA, Alaran ON, Alimi SA, Saliu RS. 2011. Hematological and biochemical studies on *Parquetina nigrescens* root extract in albino rats. J Appl Pharm Sci 1 (10): 176-179.

Panche AN, Diwan AD, Chandra SR. 2016. Flavonoids: An overview. J Nutr Sci 5: e47. DOI: 10.1017/jns.2016.41.

Pandey KB, Rizvi SI. 2009. Plant polyphenols as dietary antioxidants in human health and disease. Oxid Med Cell Longev 2 (5): 270-278. DOI: 10.4161/oxim.2.5.9498.

Patel S, Gheewala N, Suthar A, Shah A. 2009. In-vitro cytotoxicity activity of *Solanum nigrum* extract against Hela cell line and Vero cell line. Intl J Pharm Pharm Sci 1 (1): 38-46.

Reeds PJ, Burrin DG, Stoll B, Jahoor F. 2000. Intestinal glutamate metabolism. J Nutr 130 (4S Suppl): 978S-982S. DOI: 10.1093/jn/130.4.978S.

Roberts MF, Wink M. 1998. Alkaloids: Biochemistry, Ecology, and Medicinal Applications. Springer New York, NY. DOI: 10.1007/978-1-4757-2905-4.

Sopeyin AO, Ajayi GO. 2016. Pharmacognostic study of *Parquetina nigrescens* (Afzel.) Bullock (Periplocaceae). Intl J Pharmacogn Phytochem Res 8 (2): 321-326.

Spackman DH, Stein EH, Moore S. 1958 Automatic recording apparatus for use in the chromatography of amino acids. Anal Chem 30: 1190-1191. DOI: 10.1021/ac60139a006.

Statistical Package for Social Sciences (SPSS). 2012. Statistics for windows. Version 21 Armonk, NY: IBM Corp.

Surai PF. 2002. Natural Antioxidants in Avian Nutrition and Reproduction. Nottingham University Press.

Suttle NF. 2010. Mineral Nutrition of Livestock (4th Ed.). CABI, Wallingford. DOI: 10.1079/9781845934729.0000.

Traber MG, Atkinson J. 2007. Vitamin E, antioxidant and nothing more. Free Radical Biol Med 43 (1): 4-15. DOI: 10.1016/j.freeradbiomed.2007.03.024.

Underwood EJ, Suttle NF. 1999. The Mineral Nutrition of Livestock. 3rd Edition, CAB International, Wallingford. DOI: 10.1079/9780851991283.0000.

Whitmore SP, Gunnerson KJ. 2020. Acid-base and electrolyte disorders in emergency critical care. In: Shiber J, Weingart S (eds). Emergency Department Critical Care. Springer, Cham. DOI: 10.1007/978-3-030-28794-8_18.

Williams GA, Akinola OS, Adeleye TM, Irekhore OT, Oso AO, Ogunrombi JO, Williams OK. 2023. Dietary replacement of processed cassava peel-leaf blends for maize: Impact on growth performance and blood parameters of growing pigs. Anim Sci Genet 19 (1): 39-54. DOI: 10.5604/01.3001.0016.3140.

Wu G, Bazer FW, Davis TA, Kim SW, Li P, Marc Rhoads J, Carey Satterfield M, Smith SB, Spencer TE, Yin Y. 2009. Arginine metabolism and nutrition in growth, health and disease. Amino Acids 37 (1): 153-168. DOI: 10.1007/s00726-008-0210-y.