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Research Article

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Feed Quality Potentials of the Aerial Parts of *Amaranthus spinosus*

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Abstract The aerial portions of *Amaranthus spinosus* which is popularly known as 'Zaki banza' in local dialect of Hausa were randomly collected from five different sampling spots in Sabon Kaura Quarters of Bauchi, Bauchi State, Nigeria and analysed for their nutritive and mineral status using various standard analytical techniques. The results of the investigation revealed that the nutrients (moisture content, ash content, crude fibre, crude lipid, crude protein and available carbohydrate) as well as mineral elements (K, Na, Mg, Ca, Cu, Zn, Mn, Fe and P) were present at different concentrations. The plant was found to contain 14.00 ± 0.08 % moisture content, 19.40 ± 0.16 % ash content, 17.27 ± 0.47 % crude fibre, 4.77 ± 0.26 % crude lipid, 17.26 ± 0.12 % crude protein, 27.30 ± 0.30 % available carbohydrate and 934.01 kJ/100 g metabolizable energy composition respectively. The plant sample was found to contain: 60,000.00 ± 0.00, 2,300.00 ± 0.00, 1,713.00 ± 0.71, 1,122.00 ± 0.41, 473.00 ± 0.03, 64.00 ± 0.02, 20.00 ± 0.00, 13.67 ± 0.01 and 2,613.00 ± 0.03 mg/kg of potassium, sodium, magnesium, calcium, iron, zinc, manganese, copper and phosphorus levels respectively. Comparison of the results with their corresponding recommended dietary allowance values indicated that *Amaranthus spinosus* aerial parts can be used in livestock feed formulation particularly for goats and sheep, although this has to be fortified with calcium and manganese that are deficient mineral elements so as to meet up with the desired recommended dietary allowance (RDA) levels.

Keywords *Amaranthus spinosus*, nutrients, mineral elements, fortified, recommended dietary allowance and metabolizable energy composition

1. Introduction

Feed is any substance of plant or animal origin consumed by the animal to provide nutritional support for the body [1]. The term "feed" is used in animal nutrition, while "food" is used in human nutrition. Human beings and other animals require food and feed to carry out essential functions which include growth, development and reproduction [2]. Livestock production occupies approximately 30.00 % of global arable land [3]. With fast depletion of natural resources, ever-increasing population pressure and the rising living standards, it is vital to diversify the present day animal agriculture to meet the increasing demand for animal products. An area of livestock production that requires significant attention is the availability of feed resources [4]. The interest in search for alternative/additional food/feed ingredients is of significance mainly due to global demand for grains which has exceeded the production and stiff competition between man and the livestock industry for existing food and feed materials [5].

Agriculture is facing a great pressure to produce greater quantities of food, feed and bio-fuel on declining land resources for the projected nine billion people on the planet by the year 2050 [6]. It is expected that agricultural production has to increase by 70.00 % in the year 2050 in order to meet with an estimated 40.00 % increases in world population [7]. The utilization of underutilized potential feed resources of plants such as *Amaranthus spinosus* can significantly contribute towards providing food, feed and vitamins to our increasing population [8].

A high proportion of the rural and urban populations in Nigeria usually resort to natural food ingredients, especially because of their availability, accessibility and affordability [9]. Improving livestock productivity has been known for ages in order to meet the animal protein requirements of man and provides many other benefits to farmers and the national economy. Nigeria is an agricultural country and livestock production plays an important role in Nigerian agriculture [10]. Food deprivation can lead to malnutrition and ultimately starvation to both human and livestock [11]. Plants are the ultimate source of food in nature. They are part and parcel of human society that combats diseases from the dawn of civilization [12]. *Amaranthus* species are plant species that are collectively referred to as the "*Amaranth"* and are generally easy to grow, nutrient-rich and underutilized pseudo-cereal plants that play vital roles against hunger and malnutrition that occur due to low rainfall conditions [13]. A native of tropical America, *Amaranthus* (meaning immortal in Greek) was a staple crop in the Aztec, Mayan, Incan civilizations that grow rapidly and have high tolerance to arid conditions and poor soils where traditional cereals cannot grow [14]. *Amaranthus spinosus* is an annual and perennial herb which belongs to the family of *Amaranthaceae* growing in length from 100 to 130 cm, much branched, monoecious herb with purplish or greenish stem, widely distributed throughout India, all tropical and subtropical regions of Africa, South-East Asia and USA [15]. The research work is aimed at exploring the feed quality potentials of the aerial parts of *Amaranthus spinosus*.

2. Materials and Methods

2.1. Sampling and Sample Treatment

The aerial portions of the plants were randomly collected from five different sampling spots in Sabon Kaura Area of Bauchi Metropolis, Nigeria with the aid of a knife on September 25, 2019. The weed was identified in the Department of Biological Sciences, Abubakar Tafawa Balewa University, Bauchi as *Amaranthus spinosus*. The samples were thoroughly washed with tap water to get rid of extraneous and adhering substances, cut into pieces, weighed, air-dried under shade for one month, reweighed, ground to powder using a previously cleaned wooden mortar and pestle, then sieved using a standard ASTM sieve to obtain the finest possible powder for analyses. The powdered sample was packaged in air-tight plastic container for further analyses.

2.2. Analytical Methods

The nutritive/proximate compositions of the weeds (*Amaranthus spinosus*) were assayed using various standard analytical methods as adopted by different scholars. The mineral compositions (K, Na, Ca, Mg, Cu, Mn, Zn, Fe and P) were determined using different standard analytical techniques.

2.2.1. Proximate/Nutritive Determinations

The moisture content was determined based on AOAC method adopted by Ilodibia *et al.*, 2014 [16]. The ash content was found based on the method adopted by Adejinmi *et al.*, 2013 [1]. Crude protein was determined (N x 6.25) using the Kjeldahl method [9], [17] and [18], crude lipid was determined after extraction with petroleum ether in a soxhlet extractor [1], [16], while crude fibre was determined by weighing 5.00 g of the analyte and acid digested using 20.00 cm^3 of 10.00 % tetraoxosulphate (VI) acid as well as 10.00 cm^3 of 0.30 eq/dm^3 of sodium hydroxide solution [1], [9]. The available carbohydrate content was found by difference [17], whilst the metabolizable energy content was also evaluated.

$$\% \, carbohydrate = [100 - (\% \, moisture + \% \, ash + \% \, crude \; protein + \% \, crude \; lipid + \% \, crude \; fibre)]$$ [17]

Metabolizable energy (kJ/100 g) = [(% protein ×17) + (% lipid × 37) + (% carbohydrate × 17)]

2.2.2. Determination of Mineral Elements

The powdered sample of the analyte (1.00 g) was acid digested with 15.00 cm^3 combinations of concentrated trioxonitrate (V) acid, tetraoxosulphate (VI) acid and tetraoxochlorate (VII) acid in a volume ratio of 5:1:1 in a conical flask [19]. The mixture was heated on a hot plate at a temperature of 80 ^oC until transparent yellow solution was formed. After cooling, the digest was filtered using Whatman Filter Paper Number 1 into a 100 cm^3 volumetric flask and water added to capacity. Calcium and magnesium were determined at their wavelengths using Atomic Absorption Spectrophotometer Model AA 220 N, whilst other mineral elements (potassium, sodium, copper, zinc, manganese and iron) were also determined at their respective wavelengths using Buck Scientific Atomic Absorption Spectrophotometer Model VGP 210 [19]. Phosphorus was determined colorimetrically (UV-Visible Spectrophotometer Model 752 N) using Vanado-molybdate method [1].

3. Results and Discussion

3.1. Results

The results of proximate composition of the aerial parts of *Amaranthus spinosus* are shown in Table 1, whilst those of the mineral composition (mg/kg) are depicted in Table 2.

Table 1: Proximate Composition of the Aerial Parts of *Amaranthus spinosus* Plant

Nutrients	% Composition
Dry Matter	86.00 ± 0.08
Moisture Content	14.00 ± 0.08
Ash Content	19.40 ± 0.16
Crude Fibre	17.27 ± 0.47
Crude Lipid	4.77 ± 0.26
Crude Protein	17.26 ± 0.12
Available Carbohydrate	27.30 ± 0.30
Metabolizable Energy (kJ/100 g)	934.01

Values are mean ± standard error of the mean (n = 3).

Table 2: Mineral Composition (mg/kg) of the Aerial Parts of *Amaranthus spinosus*

Mineral Elements	Composition
Sodium	2,300.00 ± 0.00
Potassium	60,000.00 ± 0.00
Magnesium	1,713.00 ± 0.71
Calcium	1,122.00 ± 0.41
Iron	473.00 ± 0.03
Zinc	64.00 ± 0.02
Manganese	20.00 ± 0.00
Copper	13.67 ± 0.01
Phosphorus	2,613.00 ± 0.03

Values are mean ± standard error of the mean (n = 3).

3.2. Discussion

3.2.1 Proximate Concentrations

Table 1 shows the observed proximate composition of the dried matter of the aerial portions of the analyte (*Amaranthus spinosus)*. The percentage moisture content of the sample solution was found to be 14.00 %. The observed moisture content is very low compared to literature value of 62.33 % found in *Musa sapientum* (banana) peels [17]. The observed value is however higher than reported literature value of 7.02 % found in *Moringa oleifera* seeds [11]. Feed with low moisture level are often more desirable than those with high moisture level. Animal feed having moisture composition greater than 15.00 % are likely to favour microbial growth [17]. Low moisture content in feed is significant in its stability, susceptibility of microbial pollution and is also vital in feed storage [17].

An ash level of 19.40 % was found in *Amaranthus spinosus* aerial parts. This value is higher than 9.08 % ash content found in whole *Typha domingensis* plant [20]. The concentration of ash in a plant is an index of its mineral composition that is relevant to animals in the prevention of some blood related diseases and is also necessary for blood coagulation. An animal feed with a fairly high level of ash is needed. This is because it is required in the provision of magnesium and calcium that are needed for the formation of bone [21]. Based on the level of ash determined in the aerial parts of *Amaranthus spinosus*, it is therefore evident that the plant is favorable in feed formulation.

The observed crude fibre value (17.27 %) is higher than 10.17 % found in the peels of *Solanium tuberosum* (Irish Potatoes) [22] and it is also higher than the value (8.37 %) found in the peels of *Musa sapientum* [17], but compares favourably well with 17.46 % obtained in whole *Typha domingensis* plant [20]. The aerial parts of the plant (*Amaranthus spinosus*) is therefore suitable in feed formulation for ruminant animals (cattle, sheep and goats). This is because the animals are capable of fermenting fibre for energy [20], [23]. Fibre in animal feed is essentially used as a measure of value in feeding stock feeds as well as in poultry. It also aids in reducing some diseases in animals [20]. The health benefits of fibre-rich food cannot be over-emphasized. Fibre enhances the intestinal absorption of nutrients, prevents colonic cancer, reduces the incidence of cardiovascular diseases, lowers inflammatory responses, blood pressure, glucose and cholesterol levels as well as promotes digestion and waste elimination [24].

Low crude lipid content was found (4.77 %) and this low experimental value compares relatively well with the low values of 5.99 %, 1.90 % and 1.50 % respectively reported in related studies [17], [20], [22]. Lipid provides very good sources of energy and also aids in the transport of fat soluble vitamins, insulates and protects internal tissues as well as contributes to important cell processes [25]. The low crude lipid value can enhance the storage life of ruminant feed by decreasing the probability of developing rancidity. The experimental value would therefore, not be a good source of fat-soluble vitamins, but can contribute appreciably to energy contents of the animal feed [17].

A crude protein level of 17.26 % was found in the aerial parts of *Amaranthus spinosus* plant (Table 1). Feed with a crude protein content of 8.00 % (approximately 1.30 % nitrogen) is regarded as insufficient as this cannot provide the minimum concentrations of ammonia needed by ruminant animals. The observed value (17.26 %) in the present study is higher than the threshold protein value of 10.00 % needed in meeting the body maintenance of sheep and goats [22]. Protein is a substance that forms the wool, skin, muscle and most parts of the body of animals and this is also needed in the feed of animals for eggs, meat and milk production [17]. Proteins are required in diet for the provision of essential amino acids that cannot be produced by the body [26]. Amaranthus spinosus can therefore, be regarded as a fairly good source of protein for some ruminant animals.

An available carbohydrates content of 27.30 % was assayed in the sample solution. The observed value is the highest of all the proximate composition found in the analyte. The experimental value (27.30 %) is however, much lower than 70.55 % determined in *Monechma ciliatum* seeds [27]. The observed value is higher than reported carbohydrate literature values of 11.32 % in *Musa sapientum* peels and 4.89 % in whole *Typha domingensis* plant [17], [20]. This indicates that the sample is a relatively poor source of energy. Carbohydrate is essential in the maintenance of animals as well as plants lives and also provides the raw materials that are needed by various industries. The plant is also relevant in high temperature feed processes due to its low carbohydrate level [20]. The low level of observed carbohydrate might possibly be responsible for the relatively low level of metabolizable energy (934.01 kJ/100 g).

3.2.2. Mineral Concentrations

The results of mineral composition of the aerial portions of *Amaranthus spinosus* plant are presented in Table 2. The value of observed sodium found in the analyte was 23,000.00 mg/kg. This value is higher than the Recommended Dietary Allowance (RDA) value of 700.00 mg/kg for goats [17]. The observed level of sodium is higher than reported literature value of 1,520.00 mg/kg found in whole *Typha domingensis* plant [20]. This shows that the analyte has adequate amount of sodium that can be used by goats and sheep. Sodium is essential to animals in regulating their gastric acids, body fluids as well as transportation of nutrients [21].

The determined level of potassium (60,000.00 mg/kg) is the highest mineral content as shown in Table 2. The observed value is far greater than the RDA value of 2,200.00 mg/kg [17]. The concentration of potassium determined in the present study is much greater than 7,920.00 mg/kg found in whole *Typha domingensis* plant [20]. This therefore shows that the aerial parts of *Amaranthus spinosus* is a good source of the mineral (potassium) for goats, sheep and even cows. Potassium is important to animals in the formation of hormones, functioning of muscles and also aids in maintaining acid-base balance in their blood [28].

The concentration of magnesium determined was 1,713.00 mg/kg. The observed magnesium level (1,713.00 mg/kg) is relatively lower than 200.00 mg/100 g (2,000.00 mg/kg) determined in *Monechma ciliatum* seeds [27]. The observed magnesium value compares well with the RDA value of 170.00 mg/100 g or 1,700.00 mg/kg [29]. A magnesium level of 120.00-180.00 mg/kg was reported to be sufficient for ruminant animals [30]. The aerial parts of the plant is therefore a vital source of magnesium for ruminant animals. Magnesium is an essential mineral element because of its importance in cardiac functions, muscle tone, production of energy as well as its relevance in the nervous system of animals [21].

The concentration of calcium determined (1,122.00 mg/kg) is less than the RDA value (2,600.00 mg/kg) for goats [17]. The determined value of calcium is much lower than literature value of 23,900.00 mg/kg found in whole *Typha domingensis* plant [20]. A calcium concentration ranging from 1,200.00 to 2,600.00 mg/kg is desired for the maintenance of lactating as well as growing sheep and cattle [31]. This shows that the level of calcium assayed in the sample solution is inadequate in feed formulation. Calcium is significant to animals for nervous system, muscular and cardiac functions as well as bones and teeth development [28].

Table 2 shows that the levels of iron and zinc are 473.00 mg/kg and 64.00 mg/kg respectively. The observed value of iron (473.00 mg/kg) is lower than 710.00 mg/kg found in *Monechma ciliatum* seeds [27]. The level of zinc determined in the present study (64.00 mg/kg) was however much higher than 1.80 mg/kg found in *Monechma ciliatum* seeds [27]. The concentrations of both elements in the sample solutions are higher than their corresponding RDA values of 350.00 mg/kg (iron) and 30.00 mg/kg (zinc) for goats [29]. This therefore, indicates that the aerial parts of the plant (*Amaranthus spinosus*) are a good source of the mineral elements (iron and zinc) for goats and sheep. Iron deficiency hardly manifest except when there are signs of parasitic infections. The mineral element (iron) is a relevant component of haemoglobin and is essential to animals in the transportation of oxygen [28], [32]. Zinc is vital in protein formation, immune system and epithelial tissue integrity [28]. The presence of zinc in the weed sample can boost immune system and improve sexual functions of animals.

The concentrations of the determined manganese and copper (mg/kg) as shown in Table 2 are respectively 20.00 and 13.67 mg/kg. The experimental level of manganese (20.00 mg/kg) is comparatively higher than literature value of 0.567 mg/100 g or 5.67 mg/kg determined in *Moringa oleifera* seeds [11]. The level of copper (13.67 mg/kg) is also higher than 0.890 mg/100 g or 8.90 mg/kg assayed in *Moringa oleifera* seeds [11]. The RDA values of these mineral elements for goats are respectively 30.00 mg/kg (manganese) and 9.00 mg/kg (copper) [17]. It is therefore evident that the level of manganese determined in the sample solution is lower than the RDA value for goats, whereas that of copper is higher. This therefore implies that *Amaranthus spinosus* is a poor source of manganese, while it is a rich source of copper. In order to meet up with the RDA values of sheep, goats and cattle, other sources of manganese would have to be fortified in the feed formulation. Manganese is essential to animals in cartilage and bone production, enzyme system, immune response and reproduction, whereas copper is significant to animals in the production and maintenance of collagen, enzyme function and the maturation of red blood cells [28].

The level of phosphorus determined in the analyte was 2,613.00 mg/kg. This is comparatively and relatively lower than the RDA value of 2,700.00 mg/kg for goats [17]. The level of phosphorus determined in the present study (2,613.00 mg/kg) is higher than 211.30 mg/100 g or 2,113.00 mg/kg found in *Musa sapientum* (banana) peels [17]. Phosphorus is important in carbohydrate metabolism of animals, alkaline-acid balance in their blood as well as for their healthy growth [17].

4. Conclusion

The observed proximate and mineral analyses of the aerial parts of *Amaranthus spinosus* indicated that the plant contains high proportions of nutrients (83.33 %) and mineral elements (72.22 %) that are required by herbivorous animals particularly goats and sheep. The weed is deficient in calcium as well as manganese and hence the need to fortify it with these mineral elements in order to meet up with the recommended dietary allowances (RDA).

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