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# Evaluation of the nutritional composition of plants used by rural farmers in the treatment of helminths

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**Introduction:** Gastro-intestinal (GI) helminths negatively affect poultry health and productivity by impairing nutrient utilization, growth, and immune function, while the prolonged use of synthetic anthelmintics is associated with drug resistance and residue concerns. Phytomedicines are widely used to control GI helminths, not only due to their medicinal properties but also because their nutritional composition may enhance host resilience and resistance to parasitism. However, information on the nutritional profiles of many commonly used anthelmintic plants remains limited. This study therefore evaluated the nutritional composition of *Aloe ferox*, *Agave sisalana*, and *Gunnera perpensa*.

**Methods:** Plant samples were subjected to proximate analysis, while mineral content was determined using atomic absorption spectroscopy.

**Results:** Crude protein and total Kjeldahl nitrogen were significantly higher ( $P < 0.05$ ) in *G. perpensa* (116.9 and 18.7 g/kg DM, respectively). Iron (907.33 ppm) and copper (699.33 ppm) concentrations were also highest in *G. perpensa* compared to *A. ferox* (iron 114.7 ppm; copper 11.0 ppm) and *A. sisalana* (iron 111.0 ppm; copper 27.0 ppm). Manganese concentration was highest in *A. ferox* (246.67 ppm), followed by *G. perpensa* (84.3 ppm) and *A. sisalana* (21.7 ppm).

**Discussion:** The nutritional profiles of these phytomedicines suggest that, in addition to their anthelmintic properties, they may contribute essential nutrients that enhance chicken resilience and resistance to GI parasitism.

## KEYWORDS

*Agave sisalana*, *Aloe ferox*, gastro-intestinal parasites, *Gunnera perpensa*, nutritional profile

## Introduction

Medicinal plants and plant-derived medicine are widely used in traditional cultures all over the world and are increasingly becoming popular in modern society as natural alternatives to synthetic chemicals (van Wyk and Wink, 2004). Among these plants are *Aloe ferox*, *Agave sisalana* and *Gunnera perpensa*. *Aloe ferox* and *A. sisalana* were shown to

be potentially toxic if excessively used (Mwale and Masika, unpublished data) and *G. perpersa* was slightly toxic (Mwale and Masika, 2012). In addition, the plants have useful anti-inflammatory and analgesic properties to ameliorate pain and swelling that could be induced by GI parasites in chickens. Furthermore, these plants are part of the few recognizable plant species in South Africa due to their distinct medicinal uses such as anthelmintic properties, particularly of *A. ferox* (Steenkamp and Stewart, 2007). Split or crushed fresh leaves of *A. ferox*, *A. sisalana* and *G. perpersa* are mixed with drinking water in the control of gastrointestinal (GI) parasites in chickens (van Wyk and Gericke, 2003; Mwale and Masika, 2009) and other livestock species (Masika and Afolayan, 2003).

Phytomedicines often contain a mixture of substances that act individually or even synergistically to improve animal health (van Wyk and Wink, 2004). Some of these compounds have nutritional benefits that include protein, carbohydrates and minerals for the nourishment of chickens in addition to medicinal benefits. These nutrients support metabolic function, boost immune function and enhances reproductive performance (Yasoob et al., 2021). As such *Aloe* is commonly used with low-income, nutritionally vulnerable children in Kansas and Wisconsin special supplemental nutrition program for women, infants and children (Lohse et al., 2006; Chidembo et al., 2024) supporting its usefulness in nutrition in addition to anti-helminthic properties. In addition to controlling GI parasites related problems, treatment of burns, and cuts, the plant is used as food and drink (Santiago-Martínez et al., 2024). However, there is insufficient information on the nutritional composition of *Aloe ferox*, *Agave sisalana* and *G. perpersa* and, consequently, warrants investigation.

Nutrition plays a crucial role in host-parasite relationships as a short-term alternative to chemoprophylaxis (Coop and Holmes, 1996; Petkevicius, 2007). Nutrition can influence development of parasitism resilience and resistance by limiting the establishment, growth, fecundity or persistence of a parasite (Coop and Holmes, 1996). According to Petkevicius (2007) nutrition can also directly affect the parasite population through the intake of anti-parasitic compounds.

Gastro-intestinal helminths impair animal productivity through reduction in voluntary feed intake and efficiency of feed utilization, morbidity and mortality (Allen and Fetterer, 2002). Disturbance in protein metabolism, in particular, and reduced absorption or retention of minerals (especially phosphorus) are particularly significant effects of GI helminths infections (Holmes, 1993; Petkevicius, 2007). Hence, presence of nutritional compounds such as vitamins and minerals that enhance intake, as well as sodium/potassium (Na/K) in particular, that are needed in the Na<sup>+</sup>/K<sup>+</sup> pump for pharmacological actions to be achieved is crucial. Also, presence of crude protein (CP) for replacing endogenous proteins lost through parasitic damage is vital.

Therefore, the objective of the present study was to determine the nutritional composition of *A. ferox*, *A. sisalana* and *G. perpersa* plant leaves used as anthelmintics in village chickens. It was hypothesized that, under similar environmental and sampling conditions, the nutritional composition of the selected plant species would differ significantly.

## Materials and methods

### Plant material collection

Fresh leaves of *Aloe ferox*, *Agave sisalana* and *G. perpersa* were collected from Centane district (32°38'63"S and 28°24'36"E; elevation 50 m) in the Eastern Cape Province of South Africa in October 2007. The materials were identified by Tony Dold, Selmar Schonland Herbarium, Rhodes University Botany Department. Voucher specimens (MMAN 2007/01), (MMAN 2007/02) and (MMAN 2007/03) for *A. ferox*, *A. sisalana* and *G. perpersa*, respectively were deposited in the Giffen Herbarium at the University of Fort Hare.

### Plant extraction

The fresh leaves were washed in cold water; spines around the leaves of *A. ferox* and *A. sisalana* were removed after which the leaves were sliced. Two hundred grams of the sliced *A. ferox* leaves were mixed with 100 ml of distilled water and blended with an electric blender for 3 minutes to obtain 200% (w/v) extract. The blended material was squeezed through a muslin cloth. Sliced *A. sisalana* fresh leaves (200 g) were mixed with 200 ml of distilled water and blended in an electric blender for 5 minutes<sup>11</sup> to obtain 100% (w/v) extract. The blended material was squeezed through a muslin cloth. Extraction of *G. perpersa* was done through the milling of 200 g of the sliced fresh leaves of the plant in 400 ml of water in an electric blender for 5 minutes, after which the extract was squeezed through a muslin cloth to obtain 50% (w/v) extract. The extract from the three plants, recovered after squeezing through a muslin cloth was freeze-dried at -50°C under vacuum using a lyophilizer (Savant Refrigerated Vapor Trap, RVT 4104, USA) and kept in a freezer at -20°C until use.

### Chemical analyses of plant extracts

Chemical analyses were done in triplicate. The samples were analyzed for moisture, ash, crude protein (CP), crude fiber (CF), total kjeldhal nitrogen (TKN) and total digestible nutrients (TDN) by standard methods of the Association of Official Analytical Chemists (AOAC, 2003). Nitrogen was determined on a Kjeltac Auto 1030 Analyser (Tecator) using selenium catalyst and 1% boric acid with bromocresol green/methyl red indicator solution, according to Kandyliis et al. (2009). The 50 ml filtrate was analyzed by the macro-Kjeldhal procedure for soluble N determination (AOAC, 2003). Calcium, Magnesium, Potassium, Sodium, Phosphorus, Copper, Zinc, Iron and Manganese were determined using the atomic absorption spectroscopy (AOAC, 2003).

### Statistical analyses

The General Linear Model (GLM) of the Statistical Analysis System (SAS, 2004) was used to determine the effect of medicinal plant species on nutritional composition.

Mean separation was computed using Tukey's W procedure (SAS, 2004).

## Results

### Nutritional composition

The nutritional composition of *Aloe ferox*, *Agave sisalana*, and *Gunnera perperna* is presented in Table 1. Most measured parameters were within ranges reported to be nutritionally relevant for poultry, with significant differences observed among plant species ( $P < 0.05$ ), except for crude fiber, total digestible nutrients, sodium, and magnesium ( $P > 0.05$ ). Ash content was relatively high in *A. ferox* (281.7 g/kg DM) and *A. sisalana* (267.5 g/kg DM), indicating substantial mineral content, whereas *G. perperna* showed a comparatively lower ash value (107.9 g/kg DM). Moisture content ranged from 10.5 to 15.7%, which falls within acceptable limits for dried plant materials intended for feed supplementation.

Crude protein content was highest in *G. perperna*, suggesting its potential to contribute to dietary protein requirements and compensate for endogenous protein losses associated with gastrointestinal helminth infections. Total Kjeldahl nitrogen values for all three plant species were within ranges reported for protein-containing botanical feed resources, with *G. perperna* exhibiting significantly higher values than *A. sisalana*. Calcium concentrations in *A. ferox* exceeded typical dietary calcium requirements for poultry, indicating its potential role as a

mineral supplement. Phosphorus levels differed significantly among species, a finding of nutritional relevance given the known impairment of phosphorus absorption during helminth infections. Potassium concentrations in *A. ferox* and *A. sisalana* were within ranges associated with electrolyte balance and  $\text{Na}^+/\text{K}^+$  pump function, whereas *G. perperna* exhibited comparatively lower potassium content.

Micronutrient concentrations varied among species but were generally within or above expected physiological ranges for poultry. Iron and copper levels in *G. perperna* exceeded typical dietary requirements, suggesting potential benefits for hemoglobin synthesis and immune function, while manganese concentration in *A. ferox* was comparatively high and within ranges associated with enzymatic and metabolic processes. Zinc content in *A. sisalana* (38.67 ppm) fell within the expected physiological range (10–50 mg/kg) for poultry nutrition (Table 2).

## Discussion

Although the nutritional and chemical composition of *Aloe ferox* and *Agave sisalana* has been reported in previous studies (Sharma and Varshney, 2012; Bhaludra et al., 2013; Santiago-Martínez et al., 2024), information on the proximate and mineral composition of these medicinal plants, particularly in relation to their use as antihelmintic resources in village chicken production systems, remains limited. This study therefore provides comparative baseline data on the nutritional profiles of *A. ferox*, *A. sisalana*, and *Gunnera perperna* relevant to poultry health and resilience to gastrointestinal parasitism. *Aloe ferox*, *Agave sisalana* and *G. perperna* contained several macro- and micro-nutrients at concentrations that fall within, or in some cases exceed, reported dietary requirements for poultry, suggesting that these plants may function as nutritional supplements rather than complete feed sources when used as anti-helminthic remedies (Dold and Cocks, 2002; Masika and Afolayan, 2003; Cocks and Dold, 2006; van Wyk

TABLE 1 Nutritive composition of *Aloe ferox*, *Agave sisalana* and *Gunnera perperna* in g/kg DM unless stated (n=3).

Chemical constituent	<i>Aloe ferox</i>	<i>Gunnera perperna</i>	<i>Agave sisalana</i>	Standard error
Ash	281.7 <sup>a</sup>	107.9 <sup>b</sup>	267.5 <sup>a</sup>	4.53
Moisture (%)	11.5 <sup>b</sup>	10.5 <sup>b</sup>	15.7 <sup>a</sup>	0.86
Crude protein	90.2ab	116.9 <sup>a</sup>	79.6 <sup>b</sup>	8.13
Total Kjeldhal Nitrogen	14.5ab	18.7 <sup>a</sup>	12.7 <sup>b</sup>	1.29
Crude Fiber	3.3	4.7	1.3	0.89
Total Digestible Nutrients	792.3	795.0	787.3	2.94
Calcium	68.9 <sup>a</sup>	23.1 <sup>b</sup>	30.3 <sup>b</sup>	1.99
Magnesium	6.9	5.4	6.4	0.39
Phosphorus	2.8a	1.5b	1.8ab	0.28
Sodium	9.2	6.7	3.2	2.70
Potassium	29.3 <sup>a</sup>	18.9 <sup>b</sup>	31.0 <sup>a</sup>	0.68
Iron (ppm)	114.7 <sup>b</sup>	907.3 <sup>a</sup>	111.0 <sup>b</sup>	54.90
Copper (ppm)	11.0 <sup>b</sup>	699.3 <sup>a</sup>	27.0 <sup>b</sup>	30.34
Manganese (ppm)	246.7 <sup>a</sup>	84.3 <sup>b</sup>	21.7 <sup>c</sup>	1.00
Zinc (ppm)	118.3 <sup>a</sup>	109.0 <sup>a</sup>	38.7 <sup>b</sup>	5.93

<sup>abc</sup> Values with the same superscript in a row are not different ( $P > 0.05$ ).

TABLE 2 Nutritionally important essential mineral elements and their approximate concentration in the animal and in diet.

Elements	Units
<i>Macro elements</i>	(g/kg)
Calcium	15
Phosphorus	10
Potassium	2
Sodium	1.6
Magnesium	0.4
<i>Micro elements</i>	mg/kg
Iron	20-80
Zinc	10-50
Copper	1-5
Manganese	0.2-0.5

Adapted from McDonald et al., 2002 mg/kg is equivalent to ppm  
The conversion factor for g/kg to % is 0.1

et al., 2008). The nutritional profile of the plant leaves in the current study indicates that these plant materials could go a long way in synergistically controlling GI helminths through improved nutrition and relieving the animal from the negative effects of GI helminths infestation.

The nutrients found in these plants are believed to benefit the chickens since farmers ideally give extracts of these plants to chickens once a month for about a week. Also, given that chickens are monogastric animals they quickly digest and absorb feed nutrients over 24 hours (McDonald et al., 2002).

The finding that the three plant species had vast amounts of water, especially *A. sisalana*, is crucial since water, in conjunction with minerals such as sodium, potassium and chloride, is essential for the replenishment of the fluids lost through diarrhea or dehydration due to GI helminths infections (MSUES, 2008). Although *G. perpersa* had the highest CP content (116.9 g/kg DM), CP was generally lower than that required by chickens (180–210 g/kg DM).

Nevertheless, presence of CP in *G. perpersa* indicates that utilization of this plant could be crucial in curbing GI helminth related problems and providing the limited nutrient particularly in village chickens where the CP level from scavenged feed is 9% (Roberts, 1998). This is supported by Sharma et al. (1973) who found that increase in dietary CP leads to a linear increase in daily gains in chickens and feed efficiency, which are impaired, together with feed consumption, by helminths infections. Rosebrough et al. (1996) reported that feeding chickens with a high protein diet improves growth, efficiency and insulin-like growth factor 1, and reduces lipogenesis. When interpreted against established poultry nutritional standards (McDonald et al., 2002), the recorded nutrient concentrations indicate that none of the three plant species alone can meet the full dietary requirements of chickens. However, several nutrients of relevance to helminth-challenged birds, particularly crude protein, calcium, phosphorus, iron, zinc, and electrolytes were present at levels that may complement scavenged diets typical of village chicken production systems. Thus, the nutritional role of these phytomedicines is best viewed as supportive and restorative, rather than curative through nutrition alone.

Petkevičius (2007) reported that feed proteins are antigens that enable the gastro-intestinal tract (GIT) to serve as the first line of defense as it is the largest immunological organ. Thus, presence of CP in the three studied plants could be crucial for complementing dietary CP for improved feed efficiency, growth, immuno-competence, impairment of the establishment of helminths, reduction of anemia and hypoalbuminemia in young growing animals (Petkevičius, 2007; Keser et al., 2008). The CP is also essential for continuous replenishment of the endogenous protein that is lost due to infections with GI helminths (Coop and Holmes, 1996; MSUES, 2008). Total Kjeldhal Nitrogen (TKN) was highest (187 g/kg DM) in *G. perpersa* further supporting the additive importance of using *G. perpersa* in the treatment of GI helminths. The CP content was also augmented by the TKN making the plants essential for the normal health of the chickens through nutrient supply. Protein quantity is

also enhanced by the presence of phosphorus that is a constituent of phospho-proteins and phospholipids; thus, it is an essential component of proteins (McDonald et al., 2002).

Crude fiber content level was reasonably low in the three medicinal plants which is a desirable attribute for diets for chickens since they are monogastric animals, they do not make efficient use of high fiber diets (Roberts, 1998). Nonetheless, a diet rich in carbohydrates is indispensable for the development of the epithelial cells, maintenance of the optimal function of epithelial cells lining the large intestines; stimulate peristalsis thereby increasing the fecal bulk and expulsion of helminths and their eggs (Petkevičius, 2007). The finding that total digestible nutrients value was nearly 79% for the three plants suggests that the plants probably have the capacity to enhance availability of nutrients to the animal for absorption, adsorption and hence metabolism leading to the nutritional enrichment of the chickens (Colditz, 2004). This may subsequently boost the chickens' resilience and resistance to GI parasite infestations (Butter et al., 2000; Coop and Kyriazakis, 2001). Medicinal plant use and the added advantage of nutritional enhancement will bridge the gap for the control of GI parasites caused by frequent use of anti-helminthics that are considered unsustainable (Coop and Kyriazakis, 2001). Anti-helminthics are expensive and out of reach for resource-poor farmers, they result in residual effects in the treated chickens and in some cases parasites develop resistance to the anti-helminthics (Vercruyse et al., 2004). The anti-parasitic compounds in these medicinal plants might impair the development of parasites in the GIT of the chickens while nutrients help nourish the chicken leading to quick recovery.

The finding that *Aloe ferox* had higher calcium content (689 g/kg DM) than *Agave sisalana* (303 g/kg DM) and *G. perpersa* (231 g/kg DM) indicates that *Agave sisalana* and *G. perpersa* could be essential remedies for GI helminths infections. The calcium levels were satisfactory especially for laying hens. This is crucial to ameliorate the damage caused by parasite infestations (Hassouni and Belghyti, 2006; MSUES, 2008). Calcium is known to play a vital role in the activity of a number of enzyme systems including those necessary for the normal functioning of the nervous system through transmission of nerve impulses and for contractile properties of muscles (Invartsen and Andersen, 2000; O'Dell, 2001). Hence this could assist in the purgative action particularly of *Aloe ferox* leading to the flushing out of parasites from the GIT. In addition, calcium is an essential constituent of living cells, tissue fluids and plasma thus provision of this element to the chickens from these plants might help replenish lost fluids and maintenance of the normal functioning of cells (Invartsen and Andersen, 2000; McDowell, 2003). Gastro-intestinal parasites can also cause bleeding in the gut (MSUES, 2008) and since calcium is involved in the normal functioning of platelets in coagulation of blood (O'Dell, 2001), bleeding could be reduced if the nutrient becomes available to the parasite infested chickens.

Phosphorus content was high in *Aloe ferox* (2.8 g/kg) followed by *Agave sisalana* (1.8 g/kg DM) and *G. perpersa* (1.5 g/kg DM) signifying that this might be crucial for the normal functioning of

the chicken's body systems. This might positively impact the synthesis of protein eventually leading to the replenishment and repair of worn out intestinal tissues (Rosebrough et al., 1996). However, there is need for a comparative study to see how the performance of village chickens administered with these extracts differ from chickens that are not administered with these plant extracts. Besides, phosphorus plays a crucial role as an electrolyte and in energy metabolism through the formation of adenosine diphosphate (ADP) and adenosine triphosphate (ATP) in the tricarboxylic acid cycle (TCA) (Mazière et al., 2007). Thus, high phosphorus levels in the three plants could promote energy metabolism, replenishment of lost fluids and, protein synthesis (McDowell, 2003) for the improvement of GI parasite affected chickens.

Although, potassium and magnesium were higher than the recommended range (Table 2) their toxic effects are rarely reported since excess of the elements is rapidly excreted through urine (McDonald et al., 2002). However, it is fundamental to exercise extreme care when using these phytomedicines. Magnesium constitutes about 30% of soft tissues and fluids composition, and it is an important enzyme activator especially of enzymes involved with oxidative phosphorylation (Laires et al., 2004). Thus the nutrient is essential for the efficient metabolism of lipids and carbohydrates leading to the replenishment of energy in the animal that might have been impaired by parasites (Ashenafi and Eshetu, 2004; MSUES, 2008).

Impaired energy metabolism leads to droopiness, reduced feed intake and emaciation (MSUES, 2008). Magnesium also helps to repair and maintain the integrity of the intestinal wall cell membrane that might have been damaged by parasites, through binding to phospholipids (Laires et al., 2004). It also is an important electrolyte, involved in growth, and improves cell membrane permeability (McDowell, 2003) leading to the improvement of nutrient absorption through the GI walls.

Presence of sodium and potassium in *Aloe ferox*, *A. sisalana* and *G. perpersa* is crucial for the Na/K pump that aids in the absorption of digested nutrients; sugars and amino acids, through the gut walls, maintenance of acid-base balance for the normal functioning of cells and osmotic regulation (McDowell, 2003). This might consequently lead to chicken resistance and resilience to parasitism through the enhancement of the immune response (due to mainly proteins) (Coop and Kyriazakis, 2001; Kahn et al., 2003).

Varying amounts of micro-elements were obtained from the three medicinal plants and some could possibly lead to toxicity. However, micro-nutrients are generally needed at a concentration not more than 50 mg/kg in animal body and required at less than 100 mg/kg in the diet of the animal (McDonald et al., 2002). Iron content for *Agave sisalana* and *Aloe ferox* in the current study was close to the range for an ideal chicken diet (20–80 mg/kg). The iron content is important for the manufacture of red blood cells in the bone marrow, which might have been destroyed by the parasites as one of their negative effects is bleeding of the intestinal walls (MSUES, 2008). This is supported by the findings in Chapter 5

and 6 where *Agave sisalana*, *Aloe ferox* and *G. perpersa* promoted production of red blood cells within the recommended levels. Thus, supply of iron from the three studied plants could curb anemia (Gebhardt et al., 2004). However, the amount of iron in *G. perpersa* is high to such an extent that it may lead to toxicity. High doses of iron can result in unpleasant side effects and iron toxicity and iron overload has been shown to increase host susceptibility to infectious diseases by enhancing the viability of invading pathogenic microorganisms (Southern and Baker, 1982). However, toxicity can only occur after prolonged oral administration of the element, and iron toxicity in livestock is not common since iron is normally bound to protein preventing it from causing oxidation that leads to oxidative stress in cells (Coop and Holmes, 1996). Nonetheless, considerable care should, be taken when using this plant in controlling parasites since chronic toxicity results in alimentary disturbances, reduced growth, phosphorus deficiency and susceptibility to parasitism (Southern and Baker, 1982; O'Dell, 2001) thereby worsening the situation.

The observed manganese and copper were higher than the amount required by chickens (0.20.5) and (1-5), respectively especially the latter element in *G. perpersa*; this suggests that *G. perpersa* has potential toxicity if used in the frequency stated above. Thus, caution needs to be exercised when using *G. perpersa* as an anti-helminthic. Manganese was high in *Aloe ferox* (246.7 ppm) and its toxicity (beyond 0.5 g/kg DM) causes retarded growth and depressed appetite. However, hens can tolerate up to 1 g/kg DM (Underwood and Suttlee, 1999). Nonetheless, extra care needs to be employed when giving the plant to the chickens to avoid manganese toxicity. Manganese is essential for hemoglobin formation, an activator of many enzymes which leads to the efficient functioning of cells and hence replenishment of the lost tissues and tissue fluids (Indrayan et al., 2005). High levels of copper might lead to paralysis since copper potentially affects the nerves, necrosis of the liver, jaundice, loss of appetite and death from hepatic coma (Gaetke and Chow, 2003). However, copper is indirectly vital for hemoglobin formation as it is present in plasma proteins such as ceruloplasmin which are concerned with the release of iron from cells into plasma, erythrocyten that occurs in erythrocytes where it is involved in oxygen metabolism. This could justify why the hemoglobin content of *Agave sisalana*, *Aloe ferox* and *G. perpersa* was maintained within the range in rats that were orally administered with the aqueous extract of these three plants (Mwale and Masika, unpublished data). Gaetke and Chow (2003) reported that zinc also removes copper from its binding site, where it may cause free radical formation. Beta-carotene, alpha-lipoic acid and polyphenols have also been shown to attenuate copper-induced oxidative damage (Gaetke and Chow, 2003). Copper is an essential component in many enzyme systems, and it facilitates iron absorption and incorporation into hemoglobin (Cham et al., 2005; Indrayan et al., 2005).

Copper is also found in pigments like turacin a feather pigment crucial in the maintenance of the chicken feathers as infested chickens tend to have ruffled feathers (MSUES, 2008). Copper also reduces cholesterol, blood pressure and uric acid, improves

glucose tolerance and alleviates thrombosis (Klevay, 2001). This could be attributed to the reason why the urea, electrolyte and creatinine were maintained in the normal levels in rats orally administered with the aqueous extract of *Agave sisalana*, *Aloe ferox* and *G. perpersa* (Mwale and Masika, unpublished data). Brawner et al. (2000) reported that hens prefer cocks that display the most saturated and reddest integumentary coloration and this coloration is impaired by parasite infections leading to infertility. Therefore, presence of copper that favor coloration is vital for chickens.

Zinc content of *Agave sisalana* (38.67 ppm) was within the concentration range (10–50 mg/kg) expected in the body of an animal, indicating that the plant could be pertinently useful in relieving helminths related problem such as anemia. Zinc is crucial for enhancing appetite (Ohinata et al., 2009) leading to increased feed intake and hence improved animal condition (Klevay, 2001). This is vital as the plant could ameliorate the problem of reduced feed intake caused by parasites infestation in chickens. Zinc is a membrane stabilizer and stimulator of the immune system and reduces chicken susceptibility to a variety of pathogens and is crucial for DNA replication, RNA transcription, cell division, and cell activation (Brown et al., 2001; Prasad, 2001). Zn also functions as an antioxidant and can stabilize membranes. Therefore, using *Agave sisalana* could reduce chicken susceptibility to GI helminths infestation and leads to the improvement of intestinal wall cells that would have been macerated and sloughed off by helminths (Kahn, 2008). Prasad (2001) also reported that zinc is crucial for normal development and function of cells mediating non-specific immunity such as neutrophils. Thus, utilization of *Agave sisalana* is vital as the plant supplies an essential element, zinc, to the chickens that could lead to the synthesis of blood components such as neutrophils, basophils and eosinophils. The previous studies showed that neutrophils and lymphocytes were within the recommended ranges 2.0-7.5 and 1.0-4.0, respectively for *Aloe ferox* and *G. perpersa*, and neutrophils were lower while lymphocytes were higher than the range for *Agave sisalana*. Eosinophils and basophils were within the range 0.00-0.45 and 0.00-0., respectively, for the three medicinal plants. Thus, *Agave sisalana* is a useful medicinal plant as it contains the element zinc that is known to stimulate feed intake after oral administration (Ohinata et al., 2009) and is crucial for the production of lymphocytes which are much needed in the gut associated lymphoid tissues that constitute the largest extrathymic site of lymphocytes (Petkevičius, 2007).

## Limitations of the study

The current study assessed nutritional composition under laboratory conditions and interpreted results using established poultry nutritional standards. However, nutrient bioavailability, interactions with plant secondary metabolites, and *in vivo* dose–response relationships were not evaluated. Consequently, while the findings provide an important compositional baseline, they do not

permit direct quantification of the nutritional contribution of these plants to helminth control under field conditions. Controlled feeding and bioavailability studies are therefore required to validate the functional relevance of the observed nutrient profiles.

## Conclusion

*Gunnera perpersa*, *Aloe ferox*, and *Agave sisalana* exhibited nutritionally relevant profiles, indicating that these plants may provide added value beyond their medicinal use. The recorded nutrients included crude protein, total Kjeldahl nitrogen, and essential minerals such as calcium, phosphorus, potassium, iron, copper, manganese, and zinc. In addition to their nutritional contribution, these plants may influence hematological and serum biochemical parameters of village chickens naturally infested with *Heterakis gallinarum*. Such effects may be mediated by the observed nutrient composition and/or the presence of potentially bioactive or toxic constituents. It is, therefore, of importance to evaluate *Aloe ferox*, *Agave sisalana*, and *G. perpersa* leaf extracts for potentially toxic effects on the hematological and biochemical parameters of village chickens. Furthermore, the present study was limited to proximate and mineral composition and did not assess vitamin content, antinutritional factors, nutrient bioavailability, or mechanisms of action *in vivo*. These aspects warrant further investigation to fully elucidate the nutritional–medicinal interactions of these phytomedicines and to support their safe and effective use in village chicken production systems.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

## Author contributions

MM: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. PM: Supervision, Writing – original draft, Writing – review & editing. RC: Writing – original draft, Writing – review & editing.

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