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Potentials and Challenges of Utilizing Forage Resources for Chicken Production

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Abstract

This paper reviews the potentials and challenges using forage resources for chicken production. Forage resources are crops either planted or are growing naturally and their processed forms used to feed animals. Grasses, legumes and fodder form forage Legume crops (e.g. *puereia*, *calapagonium*, *centrosema*, soya bean) have higher nutritive value compare to grasses such as elephant grass and maize because legumes contain more protein. They can be processed into hay, silage and meals or fed as fresh cut. Forages are rich in vitamins and chlorophyll. They could exhibit anti-oxidation property because of presence of carotenoids and flavonoids which are essential for the health of animals. The major problems, which limit the use of forage plants in feeding of chickens are the low palatability, high level of fibre, low energy and high moisture content. Furthermore, the presence of anti-nutritive substances (tannins, saponins, mimosine, trypsin inhibitor, heamoglutinins, phytate, and hydrogen cyanide) may also limit the exploitation of these forages. Processing (such as drying, boiling and fermentation) and enzyme application could reduce these limitations. Even when processed, forages should not be fed to chickens as whole feed but as supplements. Despite these limitations, forage resources have potentials in chicken nutrition in terms of cost reduction, profit maximization and sustainable supply of feed. Therefore, farmers are encouraged to include forages at recommended supplemental level in feeding of their chickens.

Keywords: Chickens; Forage resources; Limitations; Potentials; Utilization

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Introduction

Chickens are among a group of birds known as poultry which are raised for their meat and eggs. They have simple stomach and do not ruminate or chew cud. They are animals that cannot effectively digest fibrous feed (feed with high level of lignin, *cellulose* and *hemicellulose*) and depend on high quality, low fibre diet [1].

Unlike ruminants (cattle, sheep and goat), they lack in their gastro intestinal tract (GIT) required microorganisms (fungi and bacteria) to ferment fibre into products that are utilizable by them and neither do they have *cellulase* (enzyme that breaks down cellulose) and capacity to utilize non starch polysaccharides and oligosaccharides [2].

Feed constitute a major input cost involved in poultry production. Incorporation of conventional feed ingredients like maize, soybean meal, fish meal in poultry feed has increased the cost of

feed enormously and attempts have been made to utilize locally available and cheap unconventional feed resources to reduce the feed cost which will benefit farmers [3]. The rapidly increasing human population gives rise to a high demand for animal protein which calls for concerted effort and innovations to also intensify animal protein production. There is need to search for alternative feeding source(s) or supplementation by incorporating certain level of low-cost-effective feed material such to chicken feeding regime [3]. Forage feeding (pasture farming or supplementary feeding) has been suggested to fit into this category and has been regarded as one of the nutritional strategies to enhancing a rapid growth of chickens [4].

Though use of forages in feeding of chickens is not a normal practice in large scale commercial production, a good pasture is still a valuable resource for the flock [5]. Moreover poultry producers have been advised to feed forages to their animals as a supplement to a basic concentrate diet in order to meet the fibre

and some of the vitamins requirements [5]. Forages can provide a significant amount of chicken feed, reducing the amount of feed that a chicken farmer requires.

Current challenge in chicken production is the exploitation and the use of forages as supplementary feeds to boost their intrinsic potentials for better production parameters. Supplementing forage in chicken ration helps the growing animal to effectively derive maximum benefit from it, and thus helping them to grow stronger and healthier [6]. Potentials of forages and their application in nutrition of chickens to improve productivity could be exploited. In doing so, adequate information is required on them which this study aims to achieving.

Overview of forage as feed for monogastric animals

Forages are plants either fodder, grasses or legumes (Table 1) that are fed to livestock in the form of hay, silage or pasture [7]. They are readily available and cheap in the tropics. These forages could be established as pastures by farmers for commercial (large scale) poultry farming or cut from the bush by small scale farmers. It is possible to reduce feed cost by utilizing forages that are nutritive and palatable [8]. Nevertheless, for good performance animals need to consume the forage in significant amount, which could be detrimental to the health and productivity of the animals. Ultimately, efficient feeding of animals forages should be based on locally available forages of high nutritional value and the quantity of forage, nutrient composition, and the way it is delivered are fundamental [9]. It is necessary that, because of their high fibre content and low energy density, forages should be used only to an extent in feeding if better result is to be expected.

Forage legumes such as *Centrosema* (butterfly pea), Cowpea (beans) and *Glycine max* (Soya bean) for instance, are dependable sources of protein, vitamins and minerals for monogastric animals in general [10]. The seeds and leaves are rich in nitrogen, because of their ability to fix nitrogen from the atmosphere. This is made possible by the nitrogen fixing bacteria in their root nodules. Hence forage legumes are adequately supplied with protein which could be essential or vital for monogastric animals feeding, even when harvested at an advanced stage of maturity. Green legume forages e.g. alfalfa and soya bean leaves generally, have an acceptable amino acids. The amino acid composition of the forage is therefore of great importance when they are used as protein source for monogastrics [11]. Table 2 shows some potential forages and their nutritive value (proximate composition). Judging from the table, appreciable amount of protein, ash and dry matter could be readily available to birds by feeding them these forages at supplemental level.

Challenges associated with feeding forages to chickens

The presence of anti-nutritional Factors (ANFS) which interfere with nutrient utilization, high moisture content, low energy and high fibre content are major challenges in utilization of forages by single stomach farm animals [12]. Anti-nutritional factors (Table 3) are plant metabolites present in plants which

Table 1 Common Forage Resources.

Botanical Name	Common Name
<i>Centrosema pubescens</i>	Butterfly Pea
<i>Glycine max</i>	Soya bean
<i>Vigna sinensis</i>	Cow pea
<i>Phaseolus vulgaris</i>	Common bean
<i>Vicia faba</i>	Broad bean
<i>Mucuna pruriens</i>	<i>Mucuna</i> bean
<i>Stylosanthes guyanensis</i>	Stylosanthes
<i>Telfairia occidentalis</i>	Fluted pumpkin
<i>Talinum triangulare</i>	Water leaf
<i>Venonia amygdalina</i>	Bitter leaf
<i>Carica papaya</i>	Paw paw
<i>Manihot esculenta</i>	Cassava
<i>Colocasia esculenta</i>	Cocoayam
<i>Moringa oceifera</i>	Moringa
<i>Musa paradisiaca</i>	Plantain
<i>Ipomea batatus</i>	Sweet potato
<i>Panicum maximum</i>	Guinea grass
<i>Cynodon dactylon</i>	Bahama grass
<i>Mangifera indica</i>	Mango

Source: [36].

Table 2 Nutrient Composition of some Forage Resources (% DM).

Grasses	Dry matter	Ash	Crude protein	Crude fibre
<i>Dogitaria</i>	48.4	9.0	19.4	28.8
<i>Brachiaria</i>	45.4	10.6	12.9	25.6
Columbus grass	48.3	5.1	6.3	29.2
Gamba grass	33.0	8.9	10.8	26.6
Elephant grass	45.6	11.1	17.4	25.4
Rhode grass	47.0	16.7	15.3	20.6
Katambora grass	48.4	7.7	15.9	25.2
Duckweed	6.0	13.0	15.0	5.0
Legumes				
<i>Calapogonium</i>	62.5	4.47	23.5	8.98
<i>Centrosema pubescens</i>	57.7	5.48	21.0	8.52
<i>Stylosanthes gumensis</i>	60.3	4.1	16.1	28.9
<i>Lablab</i>	49.5	19.3	13.4	28.4
Cassava leaves	-	12.5	5.7	4.8
Groundnut foliages	26.9	9.4	17.5	20.1
<i>Leucaena</i> leaves	-	10.4	29.4	12.4

Source: [37,38].

have the potential to adversely affect the health and growth of animals [13]. Consumption of feeds containing anti-nutritional factors have been implicated in limiting the utilization of these forage materials by chickens. They reduce feed intake and feed efficiency [14]. Certain anti-nutritional factors such as hydrogen cyanide could lead to instant death of animals and some like trypsin inhibitor leads to gradual death, by first exhibiting stunted growth and deformities. These challenges could be overcome by processing of forages and also the amount fed to birds as supplement may not trigger deleterious actions. They have been

Table 3 Anti-nutritional Factors Content in some Forage Resources.

Forages	Anti-nutritional Factors	Effects on Animals
Coco yam leaves	Saponins	It causes cell damage by disrupting cell membrane in animal.
Plantain leaves	Tannins	It reduces the digestibility of protein and Carbohydrate, low feed intake.
<i>Stylosanthes</i>	Tannins	It reduces the digestibility of protein and Carbohydrate, low feed intake.
Alfalfa	Saponins	It causes cell damage by disrupting cell membrane in animal.
<i>Centrosema pubesens</i>	Tannins	It reduces the digestibility of protein and Carbohydrate, low feed intake.
<i>Leucaena</i>	Mimosine	It causes hair loss and liver dysfunction and in extreme cases death of the animal.
<i>Puereria</i>	Tannins	It reduces the digestibility of protein and Carbohydrate, low feed intake.
<i>Calapagonium</i>	Tannins	It reduces the digestibility of protein and Carbohydrate, low feed intake.
Soybean leaves	Haemagglutinins	It is a growth retarding substance and it is capable of agglutinating red blood cells.
Clover	Mycotoxins	Poor feed intake, inhibit vitamin B1 action, paralysis and poor growth.
<i>Vigna unguiculata</i>	Trypsin inhibitor	It prevents the digestion of protein in forage legumes.
Paw paw leaves	Azadirachtin	Drowsiness, dizziness of animals and perforation of esophagus..
Sweet potato leaves	Protease inhibitor	It reduces or prevents the digestion of protein

Source: Low [6].

reported to cause abortion, and had negatively affected weight at birth and size of litter [15]. Some anti-nutritional factors include tannins, phytic acid, saponins, cyanogenic glucosides and mimosine [16].

Tannins can be defined as any phenolic compound of moderately high molecular weight containing sufficient phenolic hydroxyls and other suitable groups to effectively form strong complexes with proteins and other macromolecules [17].

Ravindra V Later [15] reported that tannins are naturally occurring plant polyphenols with molecular weights between 500 and 3,000. These polyphenols have the ability to form stable complexes with proteins and other polymers such as cellulose, hemicellulose, and pectin. Tannins are widely distributed in plant barks, roots, fruits, leaves, and seeds and dicotyledonous plants, particularly of the *Fabaceae* family, which contains a substantial amount of tannins [18]. Tannins has a bitter or astringent taste and binds protein [19]. They reduce feed intake due to low palatability and have been reported to increase with maturity and vary between plant cultivars [15]. In cassava leaves they vary from 30-50g =/kg [15].

Cyanogenic glucosides are compounds that contain cyanide in complex form and are only toxic to animals when the hydrogen cyanide (HCN) is released [20]. According to Clarke M et al. [21] cyanide is one of the most rapidly acting toxin which affects the animal population. It is also known as prussic and hydrocyanic acid.

It was isolated from blue dye (Prussian blue) for the first time and because of its acidic nature it's also known as "prussic acid [21]. Hydrocyanic acid is a colorless volatile gas with bitter almond odor [20]. The release of free HCN is done by the action of endogenous enzymes Linamarase in damaged plant tissues and β -glucosidase within the digestive tract of animals. In animals, while acute cases of cyanide toxicity usually result in sudden death, less severe cases may lead to only gastro-intestinal disorder and growth depression [21].

According to Ganguly et al. [22] mimosine is an alkaloid substances found in *Leucaena leucocephala*, a forage legume

widely distributed in the tropical areas as a fodder tree. It has shown to be responsible for some animal disorders by interfering with trypsin metabolism by preventing iodination of tyroxine, resulting in goitre and loss of appetite, loss of hair and poor reproductive performance. Anti-nutritional factors could be reduced by heat application. For instance, the mimosine content of forages could be decreased by heating to a temperature of about 700C, or by addition of iron salt - ferrous sulphate [22].

High fibre content in forages and feed in general is detrimental to poultry. Plant cell walls are typically composed of cellulose, non-starch polysaccharides (NSP), pectin, and lignin [23]. The NSP portion of the plant is associated with anti-nutritive factors that may lead to poor nutrient digestibility of chicken [23]. Researchers have partially combated problems with NSP anti-nutritive factors by supplementing feedstuffs with exogenous enzymes because poultry cannot breakdown fibre (cellulose) as efficient as ruminants, though the ability to digest cellulose varies amongst species [15].

This is because poultry does not produce enzymes such as cellulase capable of breaking down cellulose, which is the main source of energy in fibre [1,24]. This problem could be reduced by use of enzymes [25] which will help to breakdown cellulose that is present in forages [26]. The negative effect of dietary fibre is partly as a result of reduced transit time of the ingesta in the small intestine thereby limiting the time for nutrient digestion and absorption. The extent of reduction in digestibility has shown to vary with the level of fibre [26].

Forages are made up of high moisture content which is one of the challenges in feeding chickens forages. To reduce this, forage materials should be processed to reduce the moisture content such as drying and silage making. It helps in preservation of the forage for long time, and increases the nutrient level of forages. Forage resources are low in energy (**Table 4**) content because of high moisture and fibre content. This is further compounded because greater portion of the energy is not released to the animal due to poor fibre digestion [27]. Energy rich concentrate feed should be fed and forage should be fed as supplement and not as a whole diet.

Table 4 Energy Content of some Forages.

Forages	Metabolizable Energy (Mcal/Kg)
Alfalfa	1.07
Blue grass	0.91
Blue joint	0.95
Smooth Brome grass	1.03
Oat Hay	1.02
Timothy grass	0.92
Cocoyam leaves	0.93
Centrosema	0.41
Sweet potato leaves	0.82
Cassava leaves	1.12
Fluted pumpkin	0.56
<i>Leucaena</i>	0.16
Plantain leaves	0.55
<i>Moringa oleifera</i>	0.53
Ducked weed	0.35

Source: [39].

Presence of non-protein nitrogen (NPN) in forages has been reported and chickens do not thrive on these compounds. Non protein nitrogen is a term used in animal nutrition to refer collectively to compounds such as urea, biuret, nitrates and ammonium compounds (acetate, bicarbonate and bicarbonate of ammonium) which are not protein but could be a source of nitrogen to animals especially ruminants [28]. Animals with simple stomach cannot make use of large concentration of these compounds because of lack of enzymes and bacteria to break them down and synthesize them into microbial protein as in ruminants. Many common feedstuffs fed to livestock contain some non-protein nitrogen. Forages contain more non-protein nitrogen than concentrates. Corn silage could contain as much as 50% of its total nitrogen as non-protein nitrogen, while alfalfa hay contains 10-20% of nitrogen in this form [29]. The use of fertilizers such as urea, NPK mixture, nitrate and ammonium salts could increase NPN content of forages especially those in pasture [30].

Materials and Methods

Methods of reducing anti-nutritional factors in forages

The anti-nutritional factors in forages can be reduced using the following under listed methods:

Soaking

Soaking is used to remove anti-nutritional factors which are soluble which can be discarded with the soaking solution. Factors that affect the extent of removal of the anti-nutritional factors when soaking method is used are; soaking temperature, length of soaking and solubility of the anti-nutritional factors [31]. Soaking of feedstuffs can remove some of the anti-nutritional factors such as enzyme inhibitors and oligosaccharides [32]. Addition of salts and alkali in the solution increases the permeability of cell membrane, increasing the amount of anti-nutrition leaching as well as some loss of desirable nutrients such as soluble vitamins. Therefore, this method does not eliminate all the anti-nutritional factors in different feedstuffs [32].

Heat Treatment

Heat treatment as a method of removing anti-nutritional factors from feeds and feedstuffs is widely accepted as an effective means of inactivating thermo-labile anti nutritional factors [33]. This could be dry or wet heat application. Dry heat application includes frying, toasting, sun and oven drying. Wet heat application is by cooking, boiling or steaming. The nutritive quality of most tropical legume grains, particularly cowpea, soybean, pigeon pea, lima bean and winged beans is notably improved by heat treatment [33]. Heat treatment usually is a process applied before legumes are used in the human diet. This improves protein quality by inactivating anti-physiological factors particularly trypsin inhibitor and haemagglutinins by unfolding the protein structure, thus making them more susceptible to attack by digestive enzymes. Moist heating is often more effective than dry heating and the degree of inactivation is governed by temperature duration of heating and particle size [16].

According Akande et al. [34] boiling or cooking is used to remove anti-nutritional factors that are heat labile such as trypsin and chymotrypsin inhibitors as well as volatile compounds. Some insoluble compounds such as saponins, flatulence factors and phytates may not be affected by cooking. They maintained that about 30-40% of polyphenols could be removed from feedstuffs by boiling and then discarding the boiled water solution. Phytochemical analysis of raw and cooked feed samples showed that cooking for 60 minutes at 100°C is enough for the elimination of most of the thermo-labile anti-nutritional factors in the jack bean such as cyanogenic glycosides, terpenoids, saponins and alkaloids. Also, two hours of boiling could completely eliminate trypsin inhibitor activity in jack bean and 3 hours of boiling is needed to render legume free from lectin [34]. During cooking and boiling some water soluble nutrients could leach out thereby reducing the nutritional quality of the forage [16].

Fermentation

Fermentation of forages is a process used to improve the nutritive value of forages and at the same time preserve them. This is a traditional method used in removing anti-nutritional factors from forages and some feedstuffs. It is a widely used method. The fermentation is carried out by micro-organisms living in the forage under anaerobic condition. The biological process involves lowering of the pH in the forage to a point where no organism, mold or bacteria could function [35]. The pH is lowered by lactic acid produced by the micro-organisms especially *Lactobacillus* Spp. (lactic acid bacteria). *Lactobacillus bacterium* consume forage carbohydrate for their energy and in so doing anti-nutritional factors present in the forage are removed by the bacteria.

The production of modern chicken requires sustainable supply of feed, and in this regard forages fit in. The tropical ecosystems have a huge natural potential for all year round production of forage plants, many of which are valuable sources of nutrients for monogastric animals. Good forage meets the majority of nutritional requirements of monogastric animals. Monogastric animals produce better when fed forages as supplement in

conjunction with a concentrate feed. However, forage feeding should not form the bulk of the feed and should be given at recommended level that will not cause detrimental effect to the health and productivity of the animals [36-39].

Feeding Trials using different forms of Forage Resources

Several feeding trials have been conducted to unveil the potentials of forages in feeding of chickens. Different forms (fresh and meals) were used. In their own feeding trial [40] observed that feeding of *Gliricidia* leaf meal up to 5% in the diets for chicken layers did not impart negatively on productivity parameters. As shown in Table 5 values of the hen day, egg weight, shell thickness, and yolk index of layers that consumed diet containing 5% of *Gliricidia* leaf meal were similar to those that did not consume the leaf meal. Looking at the feed intake, though the feed intake of layers that consumed the leaf meal had lower feed intake compared to the control but the lower feed intake did not reduce their egg production. Invariably this will translate into profit maximization because less feed was used to achieve optimum production. Another significant characteristic of forages that played out in their feeding trial was addition of colour to the egg yolk which was increased as the level of *Gliricidia* leaf meal was increased. Good yolk colour attracts consumers which increases demand for the egg. Nutritionally it indicates that the eggs contain more carotenoids which are precursors of vitamin A.

Also Iheukwumere et al. [41] reported that 5% of cassava leaf meal could be included in diets for finisher broiler chickens without detrimental effects. Their report shown in Table 6 indicated that

Table 5 Effect of *Gliricidia* Leaf meal on Performance and Egg Quality Parameters of Layers.

Parameters	0	5	10	15	SEM
Body weight gain (g)	0.42 ^a	0.36 ^a	-1.43 ^b	-11.91 ^b	1.05
Feed intake (g/d)	123.9 ^a	120.7 ^b	117.9 ^c	116.6 ^d	2.73
Hen day (%)	86.9 ^a	85.3 ^a	76.0 ^b	65.8 ^c	2.73
Egg weight (g)	58.8	57.8	59.9	57.1	0.61
Feed/kg egg (kg)	2.45 ^c	2.48 ^c	2.61 ^b	3.15 ^a	0.10
Shell thickness (cm)	0.33	0.33	0.33	0.33	0.002
Yolk index	0.39 ^b	0.40 ^b	0.42 ^a	0.42 ^a	0.005
Yolk colour	1.0 ^d	2.25 ^c	3.63 ^b	5.88 ^a	0.47

abcd: Means with different superscripts on the same row are significantly different (p<0.05)
Source: [40].

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Table 6 Effect of different dietary levels of Cassava leaf meal on the performance of finisher broiler.

Parameters	0	5	10	15	SEM
Performance					
Initial body weight (g)	670	668	655	648	5.50
Final body weight (g)	2073 ^a	2070 ^a	1638 ^b	1636 ^b	6.54
Daily gain (g)	40.50 ^a	40.10 ^a	27.10 ^b	27.80 ^b	2.68
Daily feed intake (g)	143 ^a	148 ^a	130 ^b	128 ^b	0.24
Feed: gain ratio	3.53 ^a	3.70 ^a	4.78 ^b	4.60 ^b	0.15
Abdominal fat (g)	2.34 ^a	1.84 ^a	1.63 ^b	1.61 ^b	0.11
Nutrient digestibility (%)					
Dry matter	80.10	70.10	67.0	65.0	5.98
Crude protein	73.30	64.30	54.30	53.10	3.69
Crude fibre	65.45	62.42	56.53	55.20	2.51
Ash	56.21	57.20	62.76	64.50	1.03

ab: Means with different superscripts on the same row are significantly different (p<0.05)
Source: [41].

all growth parameters (final live weight, daily gain, feed intake, feed: gain ratio) and abdominal fat of birds that consumed 5% cassava leaf meal were the same as the control. In terms of digestibility, dry matter, crude protein, crude fibre and ash were digested similarly.

Leucaena leucocephala leguminous forage has also been reported to impart positively on performance of chickens. In feeding trial using *L. leucocephala* [42] maintained that addition of 7% *L. leucocephala* leaf meal to chicken diet improved crude protein and metabolizable energy utilization. According to them, at 21% the leaf meal did not impart negatively on feed intake, weight gain and feed: gain ratio.

Result and Conclusion

Forages (grasses and legumes) are natural resources which could be exploited in feeding of chickens. Their use is sustainable, cheap and their availability is not in doubt. Exposure of chickens to forage diets will improve their immunity (health) and productivity. Farmers could increase their profit by incorporating forages to the diets or direct feeding of fresh forages. However, forages in whatever form should not form bulk of the feed as this will reduce performance due to low energy intake.

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