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Review article

Hyacinth beans (*Lablab purpureus*) as an emerging plant protein source for animal production: A review

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Abstract

Feed scarcity is the primary limiting factor to small ruminant livestock production in developing countries; an extensive system of management provides poor quality roughages/crop residue, which has low crude protein and high crude fibre. However, conventional protein sources have become short in supply and often unavailable, due to rivalry between man and animals for plant protein. These challenges predispose to decreased feed intake, irregular growth and reproductive performance, and marked fluctuations in seasonal live weight. In the struggle to improve the utilization of such poor-quality roughages, there is a need to evaluate the hyacinth bean, which is a non-conventional forage legume that has no direct human food and industrial value and reaches its full potential for herbage yield and quality in the late dry season when other fodders are scarce. The hyacinth bean provides adequate dry season supplementation and improves the productivity of grazing during the dry season; In conclusion, the Hyacinth bean (*Lablab purpureus*) is a non-conventional proteinaceous plant widely grown throughout the year for animal consumption in the tropics. It is a drought resistance legume with no direct human use and industrial value and reaches its full potential for herbage yield and quality in the late dry season when other fodders are scarce. Hyacinth bean fodder improves the utilization of poor-quality roughage or crop residues with crude protein of 12 to 19 %, and it is cheaper, palatable, nutritionally adequate and safe for livestock feeding. The seeds contain high protein (24 to 28%) with the potential to meet the nutritional requirements of livestock. Lablab seeds contain some anti-nutritional compounds, so it is necessary to process them before feeding ruminant and monogastric animals as inclusions or feed supplements in addition to conventional feeds.

Keywords: Forage legume, Hyacinth bean, Non-conventional feed, Roughages, Ruminants.

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INTRODUCTION

Feed scarcity is the major limiting factor in tropical Africa to small ruminant production (Adjorlolo et al., 2014). Roughages such as rice hay, maize stalk, bean hay and corn husk are commonly used, which declines rapidly in quantity and quality during the late dry season (Ademosun, 2008), and the conventional protein sources have become short in supply and often unavailable due to rivalry between man and animals for plant protein (Robinson and Singh, 2001; Julia et al., 2020). These challenges result in decreased feed intake, irregular growth and reproductive performance, and marked fluctuations in seasonal live weights in farm animals (Mbahi et al., 2006). In the struggle to improve the utilization of such poor-quality roughages/crop residues and to apprehend the escalating feed cost, reduce livestock production cost and produce more livestock, there is a need to evaluate non-conventional (NCF) forage legumes (Adjorlolo et al., 2014), which has no direct human food and industrial value (Robinson and Singh, 2001; Amata, 2014). One of the NCFs available in the tropics is the hyacinth bean (Brigitte et al., 2010), which provides adequate dry season supplementation and improves the productivity of grazing (Murphy and Colucci, 1999). However, the use of plant proteins in livestock feed production has been a focus of much research in recent years (Naeem et al., 2020). For these reasons, this review deals with the development of hyacinth bean as a livestock feeds. Hyacinth bean is a non-oilseed legume, which generally contain moderate amount of protein and may be considered as a suitable source of functional protein, due to the good balance of amino acids, their high bioavailability and their relatively low levels of anti-nutritional factor (Chavan et al., 2001; Subagio, 2005).

Hyacinth bean combines a great number of qualities that can be used successfully under various conditions, its first advantage is its adaptability, not only drought resistant, it is able to grow in diverse range of environmental conditions worldwide, staying green during the dry season, it has been known to provide up to six tones of dry matter per hectare and is palatable to livestock, it is an adequate source of much needed protein and can be utilized in several different ways, in several experiments, it has been observed to increase livestock weight and milk production during the dry season, lablab is a legume that thrives well in the dry season in the tropics and sub-tropical countries of the world. It is usually sown after the normal cropping season, thereby acting as a buffer crop for ruminant feed during the dry season (Murphy and Colucci, 1999).

ORIGIN AND DISTRIBUTIONS OF HYACINTH BEAN

Hyacinth bean is a non-conventional leguminous crop widely grown worldwide (Adebisi and Bosch, 2004). The Hyacinth bean was discovered in 1500 BC (Maass et al., 2010; Kumanan et al., 2020). English language common names include hyacinth bean, lablab-bean, *Lablab purpureus, Dolichos lablab,* bonavist bean/pea, dolichos bean, seim bean, lablab bean, Egyptian kidney bean, Indian bean, bataw and Australian pea (Hauze et al., 2016). It originated in India (Murphy and Colucci, 1999) or Africa (Cook et al., 2005) and belongs to the family Fabaceae, Sub Family Papilionoidea, and Species: *Lablab purpureus* (*Dolichos lablab*) (Gowda, 2013). Hyacinth bean was introduced to Africa being an important subsistence farming crop 8000 years ago (George, 2011).

GROWTH AND DEVELOPMENT OF HYACINTH BEAN

Hyacinth Bean can be grown all year round and produce pods 60 days after sowing and continue up to 120 days; mature seeds are harvested 150 to 210 days after sowing (Murphy and Colucci, 1999). Initially, growth is slow, but once established, it competes with weeds; currently, in the United States, it is used as an ornamental crop in the cut flower industry (Stevens, 2012). Hyacinth bean is a bushy, climbing, branching, pubescent herbaceous bi-annual or short perennial crop, often grown up to 6 meters tall, with a well-developed tap root with many laterals and well-developed adventitious roots. Leaves alternate, trifoliolate; leaflets broadly ovate, 5 to 15 x 4 to 15 cm herbaceous stem that can grow up to 3 feet (Sheila et al., 2017).

The flowers grow in clusters on an un-branched inflorescence at the angle between the leaf and the main stem (Cook et al., 2005). Depending on their variety, hyacinth beans have white, blue, or purple flowers. The seedpods are 4 to 5 cm to 10 cm long, smooth, flat, pointed and contain 2 to 4 seeds. Depending on the variety, the seeds can be white, cream, pale brown, dark brown, black, or mottled (Valenzuela and Smit, 2002). Seed thickness (cm) 0.40 ± 0.03, Seed width (cm), 0.74 ± 0.05, Seed length (cm), 1.05 ± 0.10, 10 Seeds volume (ml), 1.91 ± 0.399, Seed weight (g), 0.2334 ± 0.0287, Seed longitudinal surface, area (cm2), 0.8466 ± 0.1253, Seed husk thickness (mm), 0.10 ± 0.01, Percentage after de-coating (%) 83.2128 ± 1.1077 (Subagio, 2005).

a. Creamy white **b. Black** **c. Dark brown**

Figure 1 Hyacinth bean seed varieties (Graham et al. 1986)

Hyacinth Bean can out-yield conventional crops, especially during the dry season, and is a fodder crop of great significance (Cook et al., 2005). Hyacinth bean can also grow in drought or shady conditions because it is drought resistant than the standard beans and access soil water 6 feet deep (Maass et al., 2010). It has been successfully grown in the Southern United States from sea level up to 6,500 ft. (FAO, 2014). Germination is epigeal and typically takes five days, with an average of 90 % germination, and cultivars start fruiting 60 to 65 days after sowing and continue for 90 to 100 days (FAO, 2017).

ADAPTATION OF HYACINTH BEAN

Survival and distribution of plants under diverse climatic conditions, including high temperature, salinity, and drought, are determined by their genetic and biochemical ability to respond to the environment (Maass et al., 2010). Hyacinth bean is adaptable to broad areas under diverse climatic conditions, such as arid, semi-arid, sub-tropical and humid regions where temperatures vary between 22 to 35 °C, lowlands and uplands and many types of soils ranging from sandy to clay soil, with soil pH varying between 4.4 and 7.8. It does not grow well in saline or poorly drained soils but under acidic conditions (Valenzuela and Smith, 2002).

Hyacinth beans can grow in drought or shaded conditions and areas with an average annual rainfall of 630–3050 mm (Cook et al., 2005). It is more drought resistant than similar legumes, such as common bean or cowpea (Maass et al., 2010). Lablab has remarkable physiological and morphological traits to adapt to various abiotic stresses (Rangaiah and Myrene, 2016).

CHEMICAL COMPOSITION OF HYACINTH BEAN

Hyacinth bean is one of the most ancient forage legumes among the cultivated plants. It is rich source of carbohydrates, protein, minerals and vitamins when compared to animal protein they are very cheap and readily available (Ariina et al., 2021). Proximate composition and fatty acid analysis of hyacinth beans were not given attention locally, though it might be a good source of valuable nutrition for animals and humans (Shahdat et al., 2016).

Proteins

Hyacinth bean plays an important role in protein nourishment as it contains 20-30% protein on dry matter basis 23.90g/100g (Panwar et al., 2013). It is one of the best sources of plant protein for human and animal consumption in the tropical and sub-tropical countries across the globe, particularly the poor and developing countries. However, in view of the growing concern for nutritional security in third world countries, their importance will become greater in near future (Hossain et al., 2016). Although hyacinth beans are low in the sulphur-containing amino acids such as methionine and cysteine, but the amino acid profile will limit inclusion in high density diets of monogastrics. In addition, the availability of amino acids is influenced by the presence of various anti-nutritional factors (FAO, 2017). Hyacinth bean can be used as an alternative protein source to soybean for livestock in developing countries (Smith et al., 2013).

Roy et al. (2022) reported that the proximate composition of crude protein (dry basis) isolated from hyacinth bean was 24%, carbohydrate 596.%, fat 2.9%, ash 4.22%, and moisture 9.66%.

Dietary Fiber

Dry hyacinth beans are very good source of dietary fiber among pole beans. 100g dry beans carry 25.6g or 64% of fiber (Sheahan et al., 2012). Dietary fiber works as a bulk laxative that helps to protect the colon mucosa by decreasing its exposure time to toxic substances as well as by binding to cancer causing chemicals in the colon. Dietary fiber has shown to reduce blood cholesterol levels by decreasing re-absorption of cholesterol binding bile acids in the colon (Soetan et al., 2010).

Carbohydrates

Carbohydrates as Nitrogen free extract (NFE) calculated by difference for whole raw hyacinth bean (65.85g/100g) was well comparable with the range values of 60-65g/100g for cowpea and common bean 65-70g/100g for pigeon pea. Hyacinth beans possess good quantity of resistant starch which on fermentation results in production of short chain fatty acids such as acetic, butyric and propionic acids. High carbohydrate content of hyacinth bean enables the legume to act as a good source of calories which would be anti miasmas, especially in infant nutrition (Vadivel and Janardhanan, 2000). The range in calorific values exceeds energy values of cowpea, green gram, horse gram, moth bean and peas (Rao et al., 1982).

Lipids

Lipids was categorized the lowest content among nutritional components in hyacinth bean although it constituted the primary component of human diet. Indian bean is very low in total fat (1.10%) and its contribution to the total calorie was only 2.8% (Hossain et al., 2016). Fatty acid profiles showed that oils composed of 24.2% saturated fatty acids, 18.42% monounsaturated fatty acids and 57.38% poly unsaturated acids and linoleic acids (44%) was the major constituents of fatty acids (Al-Othman el al.,1999).

Minerals and Vitamins

The nutritive value of hyacinth bean is very high with good content of minerals and vitamins (Basu et al., 2002). Sodium and potassium are useful in checking nerve irritability controlling glucose absorption and enhancing normal retention of protein during growth (NRC, 2000). Inadequate iron (5.10mg/100g) in the diet has been associated with poor learning and decreased cognitive development (FAO, 2000). Also Iron facilitates the oxidation of carbohydrates, proteins and fats (Adeyeye et al., 2014). Zinc (9.30mg./100g) is one of the many minerals that are deficient in the diet and is associated with impaired growth, reproduction and immune disorder (Adeyeye et al., 2014). Other minerals such as Calcium (130mg/100g), Copper (1.335mg/100g), Magnesium (283mg/100g), Manganese (1.573mg/100g), Phosphorous (0.372mg/100g), Selenium (8.2 µg/100g) were also present. Essential vitamins such as Folates (2µg/100g), Niacin (1.610mg/100g), Pyridoxine (0.155mg/100g), Thiamin (1.130mg/100g) and Vitamin-A 0.1IU were also found to be present (Khalid et al., 2008; USDA, 2009).

Al-Snafi (2017) reported that proximate analysis revealed that the seed powder contained 8.47 % moisture, 3.50 % ash, 1.0 % fat, 23 to 28 per cent protein, 1.21 % dietary fibre, 61.8 carbohydrates and 352.4 kcal/100 g energy depending upon cultivars or genotypes (Khalid et al., 2008).

Table 1 Proximate Compositions of Hyacinth Bean

Parameter	Seeds (%)	Fresh (%)	Hay (%)
Crude protein	23.3–28.8	12.5–24.3	12.2–19.
Ether extract	0.9–4.2	1.7–3.9	1.6–2.9
Crude fiber	7.6–12.1	22.0–36.1	27.7–37.1
Ash	3.3–4.8	7.1–16.2	5.6–15.2
Nutrient detergent fiber	22.5–51.4	36.0–53.8	25.5–71.8
Acids detergent fiber	11.5–17.1	22.8–41.4	18.0–49.9
Lignin	0.5–1.8	4.6–10.7	1.0–13.1
Calcium	0.04–0.99	0.74–2.18	0.95–2.08
Phosphorus	0.11–0.79	0.19–0.55	0.11–0.54

Source: Shahdatet al. (2016); Sheilaet al. (2017)

DIGESTIBILITY OF HYACINTH BEAN

Hyacinth beans are usually palatable for ruminants, and are excellent source of protein and energy for livestock. The protein is extensively and rapidly degradable in the rumen and provides degradable protein for microbial protein synthesis. However, the protein that escapes ruminal degradation is accessible later in the intestinal tract as undegradable protein. The levels of undegradable protein can be increased by heat treatment (Yu et al., 2004). Cooking of hyacinth beans seeds can provide much higher rumen undegradable protein than soybean meal (>12 % DM basis), which is higher than other raw or processed legume seeds such as pea or lupin (Masoero, Pulimeno and Rossi, 2005). However, cooking did not affect amino acid composition. Similarly, Yu, Goelema and Tamminga (2000) stated that cooking of beans at 136 °C for 15 min yielded the highest values of rumen undegradable protein and maintained a sufficient amount of degradable protein for microbial protein synthesis (Sharasia et al., 2017).

Furthermore, hyacinth beans has a high content of starch (energy), some of which can bypass the rumen and be digested at a later stage of the digestive tract, it content oil (linoleic and linolenic acids) and fibre is relatively low, the effective starch degradability of hyacinth bean grains in the rumen of lactating cows was above 58% (Aleksie, Grubie and Pavlieevie, 1999).

ANTI-NUTRITIVE CONTENT OF HYACINTH BEAN

Anti-nutritional factors are poisonous in most cereal and leguminous crops, limiting nutrient availability (Gemede and Ratta, 2014). Hyacinth beans contain significant anti-nutritional factors such as tannins, phytate and trypsin inhibitors, limiting their use in monogastric animal feeding (Murphy and Colucci, 1999). Anti-nutritional factors can be divided into two main groups: heat-stable and heat-labile (Gemede and Ratta, 2014).

Antinutrients with heat-stable properties which resist and are maintained at high temperatures are phytic acid, condensed tannins, alkaloids, and saponins. In contrast, the heat-labile group that are sensitive to standard temperatures and lost at high temperatures are lectins, cyanogenic glycosides, protease inhibitors, and toxic amino acids, but extensive research is still needed to discover elimination methods for stable heat antinutrients present in various food without altering the nutritional value (Abhishek et al., 2019).

Previous studies have demonstrated that animal metabolism and health could be affected by anti-nutritional factors in different ways. The effects include bloating in ruminants, reduced nutrient absorption, decreased liver cholesterol and overall growth rate, and reduced intestinal absorption of nutrients through binding to the small intestine cells (Addisu and Assefa, 2016).

Anti-nutritional factors combined with other nutrients reduce nutrient bioavailability. Trypsin and phytates inhibitors, present mainly in legumes and cereals, reduce the digestibility of proteins and mineral absorption (Mrinal et al., 2020).

Phytates

Phytic acids occur naturally in plants at various levels ranging from 0.1 to 6.0% (Gupta et al., 2015). Phytic acid is a secondary compound which concentrates naturally in plant seeds, mainly in legumes; it contains about 50 to 80% of the total phosphorous in seeds (Lott et al., 2000). Kies et al. (2006) reported that phytic acid hinders the activity of enzymes, which are necessary for protein degradation in the small intestine and stomach; it affects the bioavailability of minerals and has a strong effect on the neonates, pregnant and lactating an imals (Chan et al., 2007).

Trypsin

Trypsin inhibitors are found in most legumes, the levels present tend to vary considerably, and most legume species contain less than 50 % (Savage and Morrison, 2003). Trypsin inhibitors are one of the most relevant anti-nutritional factors; they inhibit the activity of crucial pancreatic enzymes trypsin and chymotrypsin, thereby reducing digestion and absorption of dietary proteins (Sara et al., 2017).

The localization of trypsin within the seed varies according to the legume type; for soy and fava beans, trypsin is concentrated mainly in the cotyledon (> 90 %); for other legumes such as chickpea they are distributed in the cotyledon (75.8 to 77.2 %), embryonic axis (11.9 to 15.5 %), and seed coat (10.9 to 8.7 %) (Sreerama et al., 2010).

Tannins

Tannins are phenolic compounds found in plant leaves, fruits and bark, and they consist of molecular weights greater than 500 Da (Timotheo and Lauer, 2018). One of the characteristics of these compounds is that they can precipitate protein digestibility and lead to the reduction of essential amino acids by forming reversible and irreversible tannin-protein complexes (Raes et al., 2014).

Tannins are primarily concentrated in beverages, pomegranate, berry fruits and cocoa beans, although they are also found in cereals such as sorghum and barley (Morzelle et al., 2019).

In ruminants, hydrolysable tannins are readily broken down during digestion, which can be toxic; however, leguminous forage and some seeds generally contain mostly condensed tannins. Previous studies showed that goats resist these tannins, while cattle and sheep are sensitive (Smeriglio et al., 2017).

Tannins accumulate mainly in the bran section of the legumes; when ingested, it causes the inactivation of many digestive enzymes and decreases protein digestibility (Joye, 2019).

PROCESSING OF HYACINTH BEAN

Hyacinth bean seeds can be processed using soaking in water, cooking, roasting, autoclaving, germination and in-vitro digestibility to eliminate or reduce anti-nutritional factors (Tuleun and Patrick, 2007). Other methods include chemical treatment or decortications, fermentation and sprouting (Sheila et al., 2017).

The germination method significantly increased the protein and moisture content, whereas roasting and autoclaving decreased their contents; these processing methods significantly reduced crude lipid content. Cooking presoaked seed is the most effective method for reducing the activities of trypsin inhibitors. In contrast, phytic acid was more significant in roasted samples than others (Magdi, 2007).

Soaking

Soaking is one of the methods of reducing anti-nutrient content from plants; it provides necessary moist conditions in nuts, grains and other edible seeds; it is required for germination and reductions in the level of enzyme inhibitors as well as other anti-nutrients to enhance digestibility and nutritional value (Kumari, 2018). A previous study stated that six (6) hours of soaking reduced 27.9 %, and 24 hours reduced 36.0 % of phytic acid at room temperature (Udensi et al., 2008). Soaking of beans was found to be much more effective in enhancing the minerals concentration and protein availability, accompanied by reductions in phytic acid levels (Coulibaly et al., 2011). Liu and Markakis (1987) documented that soaking of beans in water at 22˚C for 24 hours could reduce the level of other anti-nutrients but had no effect on the level of trypsin inhibitor. Soaking and cooking of beans has been associated with a higher potential of improving the nutritional value by reducing anti-nutritional factors such as trypsin inhibitors, condense tannin and phytic acid and thereby enhancing its utilization (Jain et al., 2009).

Milling

This is the traditional method of separating the bran layer from the grains. The milling technique removes anti-nutrients in the bran of grains, but this technique has a disadvantage; it also removes essential nutrients. Research on millet milling reported that the chemical composition of pearl millets was changed due to the milling process (Gupta et al., 2015).

Autoclave and Cooking

Autoclave is an application generally used for heat treatments; when it is used on cereals and other plant-based foods, it activates the phytase enzyme and increases acidity (Ertop and Bekta, 2018). The boiling of food grains reduced anti-nutrient content, which improved their nutritional value (Rehman and Shah, 2005). Soaking and cooking also significantly decreased the phytic content in legume grains and highly improved the nutritional value of foods by reducing their anti-nutritional contents (Patterson et al., 2017).

Germination

Germination is also considered a highly suitable method for reducing the anti-nutrient components of plant-based foods (Nkhata et al., 2018). Germination of seeds generally activates the enzyme phytase, thereby improving the activity of phytase-degrading enzymes. Germination commonly changes the grain's nutritional level, biochemical properties and physical features (Oghbaei and Prakash, 2016).

Fermentation

Fermentation is one of the processing methods used in Africa to make cereals crops edible and increase the nutritional quality and safety aspects of these foods because cereals are not easily consumed in natural raw forms (Galati et al., 2014). Fermentation may be a helpful strategy for reducing bacterial contamination of foods, fermented cereal products are recommended as probiotics, and it also improves the absorption of minerals from plant-based foods (Nduti et al., 2016).

Fermentation has been shown to improve the nutritional value of grains by increasing the content of essential amino acids such as lysine, methionine and tryptophan (Mohapatra et al., 2019). Previous reports observed that several anti-nutrients, including protease inhibitors, phytic acids and tannins, were reduced due to fermentation for 12 and 24 hours. Fermentation significantly lowers the content of anti-nutrients such as phytic acid, tannins, and polyphenols in cereals (Coulibaly et al., 2011; Simwaka et al., 2017).

USES OF HYACINTH BEAN

Hyacinth bean is one of the palatable legumes for livestock, and it is often sown with Sorghum and millet as intercropping (Brigitte et al., 2010). Protein isolate from the bean can be used as a food additive for improving livestock feed quality (Maass et al., 2010). The leaf has 12 to 24 % crude protein depending on the variety, and the seeds contain large amounts of vitamins and minerals with 20 to 28 % crude protein (Cook et al., 2005).

The leaves make excellent hay for ruminants, but the stem is difficult to dry and must be mechanically conditioned through crushing (FAO, 2012). Silage made from a mixture of *L. purpureus* and *Sorghum* raised the protein content of Sorghum by roughly 11 % (Heuze, 2016). Apart from using the grain, the immature pods can be used as vegetables, while the crop residue after harvest is manure (National research council, 2006). *Lablab purpureus* is used as a nitrogen-fixing green manure to improve soil quality and also returns nitrogen through leaf decay (Filipe et al., 2016). It often produces more dry matter than cowpea (Valenzuela and Smith, 2002); it has an extensive root system that improves the physical condition and function of the soil (Sheahan, 2012).

The preliminary pharmacological studies revealed that Dolichos lablab possessed anti-diabetic, anti-inflammatory, analgesic, antioxidant, cytotoxic, hypolipidemic, antimicrobial, insecticidal, hepato-protective, anti-lithia-tic, antispasmodic effects and also used for the management of iron deficiency anaemia (Al-Snafi, 2017). Apart from being a good source of protein, minerals and vitamins (Parmar et al., 2013), it also has antihypertensive property (Singhal et al., 2014).

Hyacinth bean seeds were used as an antidote for poisoning, as a treatment for cholera, diarrhoea, colic and rheumatism and as anti-helminthics (Kante and Reddy, 2013). It is consumed as a green vegetable in Africa, Asia, and the Caribbean (Maass et al., 2010; Sheahan et al., 2012).

Hyacinth beans in animal production

Soyabean and ground nut meals, which are the major sources of vegetable protein for poultry rations, have become very expensive. There is therefore the need to search for alternative vegetable proteins that will be cheaper, nutritionally adequate as replacement for these expensive meals so as to reduce production cost of meat, milk and eggs. Among these alternative vegetable proteins is Hyacinth bean Mohamed, (2002).

Hyacinth bean as animal feed

Hyacinth bean is one of the most palatable leguminous crops for animals, and it is used as forage, hay, and silage; it is often sown with sorghum or millet, and the leaf is very palatable (Adebisi and Bosch, 2004). The forage has an average protein content of about 12 to 24 %, depending on the harvest stage and is highly degradable in the rumen compared with other tropical forages (Mudunuru et al., 2008).

Hyacinth bean as forage crop

Lablab forage is a valuable source of protein for ruminants fed on low-quality roughages; Lablab should be first grazed about ten weeks after sowing, and care should be taken to ensure the stems are not eaten with the leaves because stem removal or cutting below 25 cm hampers leaf re-growth. Under optimal grazing, lablab can provide three grazing per season but does not withstand heavy grazing. Therefore, hungry animals should not enter the pasture as it may cause bloating if eaten in large quantities (FAO, 2014). Eduvie et al. (2002) reported that supplementing suckling Bunaji cows grazing on natural pasture with hyacinth bean forage (2 kg/day) increased performance and farmer incomes in Nigeria.

Hyacinth bean as hay

Lablab makes excellent hay, like alfalfa hay in quality; unlike alfalfa, lablab does not re-grow after cutting below 15 cm height; if the leaf is adequately preserved, lablab stem is coarse and fibrous, it may be challenging to dry, it has to be mechanically conditioned to hasten to cure (FAO, 2014).

Lablab hay is a valuable forage for goats and sheep and can supplement forage-based diets of low quality. In growing goats, adding lablab hay to low-quality Rhodes grass hay *(Chloris gayana)* fed *ad libitum* with maize grain increased dry matter (DM) intake (42%), nutrient digestibility and live weight gain (Mupangwa et al., 2000).

Hyacinth bean as Silage

Lablab can produce good-quality silage alone or mixed with forage sorghum or millet (FAO, 2014). When the lablab is ensiled alone, it is recommended to cut and wilt it to 30 to 35% DM over 18 to 24 hours before ensiling, increasing the concentration of soluble sugars and facilitating fermentation. Lablab can be mixed with cereal crops (maize or sorghum) which favour fermentation. Therefore, adding molasses is unnecessary (FAO, 2014).

In Nigeria, optimal results using maize/lablab silage for the growth performance of crossbred calves were obtained with 70% maize and 30% lablab (DM basis), which significantly improved animal performance during the dry season (Amole et al., 2013). Mbahi and Goska (2017) reported that lablab hay is a legume that has high crude protein content when used as a supplement to improve the dry matter intake, nutrients digestibility and weight gain of rams, and can be used as a supplement to the low-quality grass during the dry season.

Hartutik et al. (2012) reported that Lablab forage is a good source of metabolizable protein for ruminants. However, its protein is highly degradable in the rumen, resulting in a reasonably low contribution to by-pass protein.

Hyacinth bean Seeds

Lablab seeds can be included in sheep and goat diets to replace groundnut meal as a protein source in the concentrate mixture, positively affecting roughage intake, nutrient utilization, rumen fermentation and body growth with better N utilization (Sultan et al., 2010). Feeding of raw or decorticated Lablab seed in diets of growing rabbits resulted in a high cost of feeding, poor growth rate and subsequently, death of rabbits; this suggests that Lablab seeds be processed possibly before use in monogastric diets (Shaahu et al., 2014). Adding 10% processed hyacinth bean enhanced growth and feed intake in broiler chicks after soaking and boiling to inactivate the anti-nutritional factors (Elamin et al., 2013).

ANTI-OXIDANT PROPERTIES OF HYACINTH BEAN

Antioxidants can be described as an agent that can protect cells from the damaging effects caused by free radicals. Free radicals are natural by-products of cell metabolism (Jahanbani et al., 2016). Diets rich in antioxidant have reported to reduce the risk of many developing diseases. Legumes crops such as Phaseolus vulgaris L. (common beans), Glycine max (L.) Merr. Fabaceae (Soybean) and Phaseolus lunatus L. (Lima beans) have been reported to have high antioxidant potential (Chen et al., 2017; Guleria et al., 2020).

Hyacinth bean seeds contained many anti-nutritional compounds such as Ferric Reducing Property, Vitamin. C, Phenol, Free Radical Scavenging Property and Flavonoids. These anti-oxidants transform reactive oxygen species (ROS) in to less harmful chemical. Tissue or cellular damage is largely caused due to accumulation of ROS, which are formed as results of imbalances in tissue metabolism (Adekunle et al., 2023). Roy et al. (2022) demonstrated that hyacinth bean offers a good potential for use in livestock feed industry as natural antioxidants that protect cells from the damaging effects caused by free radicals which are natural by-products of cell metabolism. Guleria et al. (2020) further stated that leguminous crops have been reported to have high antioxidant potential that reduce the risk of cellular damage and many developing diseases.

CONCLUSIONS

Hyacinth bean (*Lablab purpureus*) is a non-conventional leguminous plant widely grown for animal consumption in the tropics. It is a drought resistance legume with no direct human use and industrial value and reaches its full potential for herbage yield and quality in the late dry season when other fodders are scarce. Hyacinth bean fodder improves the utilization of poor-quality roughage or crop residues with crude protein of 12 to 19%, and it is cheaper, palatable, nutritionally adequate and safe for feeding livestock. The seeds contain high protein (24 to 28%) with the potential to meet the nutritional requirements of livestock. Lablab seeds contain some anti-nutritional compounds, so it is necessary to process them before feeding ruminant and monogastric animals as inclusions or feed supplements in addition to conventional feeds. However, soaking and cooking of beans has been recommended with a higher potential of improving the nutritional value by reducing anti-nutritional factors such as trypsin, condense tannin and phytic acid thereby enhancing its utilization.

RECOMMENDATIONS

1. It is recommended that the information obtained will be helpful to policymakers in integrating hyacinth bean production into the national agricultural policies for food security.
2. In order to encourage wider adoption of *lablab purpureus*, there is a need to enlighten livestock farmers on the potential of using hyacinth bean as an alternative protein source in animal diets.
3. There is a need to invest in research and development to improve seed for mass production.
4. There should be a specific effort by the Government to standardize the processing and preservation methods that will be effective, efficient and affordable to the farmers without compromising the quality of the product.
5. There is a need for further research to explore further the pharmacological effects and other Agricultural uses of hyacinth beans.

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CONFLICT OF INTEREST

The authors have declared that there exists no conflict among the authors of this article.

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