Available online at www.scholarsresearchlibrary.com

Scholars Research Library

***J. Nat. Prod. Plant Resour*., 2015, 5 (5):7-15**
(http://scholarsresearchlibrary.com/archive.html)

ISSN : 2231 – 3184
CODEN (USA): JNPPB7

The use of non-conventional feed resources (NCFR) for livestock feeding in the tropics: A Review

Amata I. A.

Department of Animal Science, Delta State University Asaba Campus, Delta State Nigeria

---

ABSTRACT

The use of non-conventional feed resources (NCFR) either as replacement or as a supplement in the nutrition of livestock is discussed in this paper. The shortage of feed resources for livestock and poultry feeding diverted majority of research in the field of animal nutrition to look into possibilities to overcome this nutritional crisis. A possible and perhaps the most viable proposition could be the inclusion of non-conventional feed resources in livestock rations with suitable and complete feed technology that can utilize the feed sources with maximum efficiency. For the purpose of this review, potentially available NCFR include agro-industrial by products, some common tropical browse plants and leaf meals. It is known that some of these products are low in energy, proteins and contain high concentrations of lignin, silica and several anti- nutritional substances. Numerous multipurpose browse plants and leaf meals have been identified as having significant potential in agro-forestry systems in the tropics. Browse plants that have been identified and have recently been studied include Gmelina arborea, Myrianthus arboreus, Terminalia catappa, Dacroydes edulis, Parkia filicoidea and Tephrosia braceteolata. Protein from plant leaf sources is perhaps the most naturally abundant and cheapest source of protein, such that there has been growing realization in use of plant leaf meals in livestock diets. Several authors have conducted studies on these leaves to determine their nutritive values and usefulness in livestock nutrition. These include such plants as wildflower, Centroceama pubescens, cassava leaf meal, Microdermus puberula leaf meal, Vernonia amygdaliana leaf meal and Gliricidia sepium leaf meal. Results obtained from these studies have shown beneficial and economic values from the inclusion of these leaf meals in the diet of livestock.

Key words: Non-conventional feed resources browse plants, leaf meals, agro-industrial by products, animal organic wastes.

INTRODUCTION

In animal production systems, it is traditional to provide livestock with conventional feeds such as cereals, oil cakes and meals to all categories of livestock including ruminants, non-ruminants and poultry. This practice has been made possible by the use of developed technology that is applicable and viable mostly in temperate environments. This developed technology often advocated in text books is recommended with the belief that it is also applicable to tropical environments. This is coupled with the fact that there has been little demonstration of alternative technology developed in and suitable to specific situations in tropical environments (FAO, 1985). Specialized technologies on feeding systems developed in the temperate environments might not be entirely appropriate for the needs of the developing countries in the tropics. A major constraint to the use of feeding systems adapted to temperate environments is that it is often irrelevant and unrealistic in the tropical environments. Such systems effectively increase the dependence on traditional feeds without taking into cognizance the issue of feed storage and feed shortages thus contributing to the mounting pressure on world feed resources.

A major gap exists between the demand and supply of conventional feed resources for feeding livestock in the world. In order to manage this problem of demand and supply, it is essential to increase the availability of conventional feed resources for the different livestock production and management systems. One method is to exploit the use of non-conventional feed resources (NCFR) in livestock production systems (Ben Salem et al, 2004). Potentially available NCFR include crop residues, agro-industrial by-products, leaf and seed meals, such as the leaves and seeds of the African pear (*Dacroydes edulis*), *Gliricidia sepium* leaf meal, the seeds and leaves of *Gmelina arborea*, the leaves of *Myrianthus arboreus*, browse foliage, slaughter house by-products, cassava leaf meal, tapioca waste, tea waste, mango seed kernels and animal organic wastes. Most of these feed materials are low in energy, protein, minerals and contain high amounts of anti-nutritional components (Ben Salem et al, 2004). The major constraints to the use of NCFR are collection, storage, dehydration (due to high moisture content) and detoxification processes. There is an urgent need for processing techniques that are economic and practicable.

Non-conventional feed resources (NCFR) generally refer to all those feeds that have not been traditionally used for feeding livestock and are not commercially used in the production of livestock feeds. Several known examples include palm leaf meals, palm press fiber, cassava foliage, spent brewer's grains, sugar cane bagasse, rubber seed meal and some aquatic plants (Chadhokar, 1984). Defined in this manner non-conventional feed resources can be looked at as covering a wide diversity of feeds and their nutrient contents. A common feature about feeds is that the traditional feeds of tropical origin tend to be mainly from annual crops and feeds of animal and industrial origin. In this sense, the term NCFR could really be more appropriately referred to as "new feeds", and this term is increasingly being used. Thus the term NCFR has been frequently used to describe sources such as oil palm by-products, single-cell proteins and feed materials derived from agro-industrial by-products of plant and animal origin, poor-quality cellulosic roughages from farm residues and other agro-industrial by-products such as slaughter-house by-products and those from the processing of sugar, cereal grains, citrus fruits and vegetables from the processing of food for human consumption. This list can be extended to include derivatives from chemical or microbial processes as in the production of single cell proteins. However it is sometimes difficult to draw a distinct line between traditional feeds and NCFR. In some countries such as India and Pakistan, what may now be classified as NCFR may in fact be conventional /traditional owing to the fact that it may have been in use as livestock feed over a long time, an example is wheat straw which is very widely used in these two countries, in addition, the availability of NCFR, especially of plant origin, is dependent to a large extent on the type of crops being cultivated and the prevailing degree of application of the crop technology (Younas and Yaqoob, 2005).

Quality/Characteristics of NCFR

According to reports (FAO, 1985), non-conventional feed resources like conventional feed resources have several characteristics worthy of note.

a) They are the end products of production processes and consumption that have not been used, recycled or salvaged.

b) They are mostly of organic origin and can be obtained either in a solid, slurry or liquid form.

c) The economic value of these non-conventional feed resources is usually less than the cost of their collection and transformation for use and consequently, they are discharged as wastes.

d) Feed crops which generate valuable NCFR are usually excellent sources of fermentable nutrient molecules such as cassava and sweet potato and this is an advantage to livestock especially ruminants due to their ability to utilize inorganic nitrogen and non-protein nitrogenous sources.

e) Fruit wastes such as banana rejects and pineapple pulp by comparison have sugars which are energetically beneficial.

f) The majority of feeds of crop origin are bulky poor-quality cellulosic roughages with high crude fiber and low nitrogenous content which are suitable for feeding mostly ruminants.

g) Some of these feeds contain anti-nutritional components which have deleterious effects on the animals and not enough is known about the nature of the activity of these components and ways of alleviating their effects.

h) Non-conventional feed resources have considerable potential as feed materials and for some; their value can be increased if there were economically viable technological means for converting them into some useable products.

i) Substantial information is required on chemical composition, nutritive value, the presence of anti-nutritional components and value in feeding systems.

Generation of NCFR

The generation of non-conventional feed resources is essentially from agriculture and various agro-based industries and is a function of many factors. Such factors include the quantity and quality of the materials produced which is dependent on the prevailing agro-climatic conditions and cropping patterns, the type of raw materials, the production process, the production rate, the type of inputs used, the regulations affecting product quality use and the constraints imposed upon effluent discharge (Devendra, 1985)

Most non-conventional resources are usually regarded as waste which is an inaccurate description of this group of materials. They can be regarded as waste when they have not been shown to have economic value. When such waste can be utilized and can be converted by livestock to valuable products which are beneficial to man, they become new feed materials of importance. In addition, they can be used to supplement the existing limited feed resources. Recycling, reprocessing and utilization of all or a portion of the wastes, offers the possibility of returning these materials to beneficial use as opposed to the traditional methods of disposal and relocation of the same residues. The demonstration of potential value can thus make any of these waste products new feeds of value and importance.

Constraints to the uses of non-conventional feed resources.

Non-conventional feed resources are presently underutilized and there are several reasons for this.

· Production is usually scattered and in some cases, the quality produced is low especially for use in processing of feed.
· Sometimes cost of collection can be unusually high, for example, rubber seeds.
· Processing of NCFR is usually difficult and can be problematic in certain cases.
· Lack of managerial and technical skills in the utilization of such feeds *in situ*.
· Limitation in the end uses of the products produced.
· The uncertainty about the marketability of the end products.
· Small farmers who form the backbone of traditional agriculture in tropical regions have neither the resources and know-how nor the quantity of residues to make any individual impact (Devendra, 1983).
· The availability in terms of time, location, seasonality and storage.
· Low nutritive value
· High moisture content
· Presence of anti-nutritional factors
·Lipid peroxidation (rancidity of high fat products)
· Mould growth such as aflatoxin which may cause toxicity.

Agro-industrial by-products:

The increasing human demands for several food types such as vegetables, wine, fruit juices etc, has led to a considerable decrease in available farming lands due to the increase in the cropping of these foods. Consequently, this leads to an increase in the availability of agro-industrial by-products (AIBPs) such as molasses, brewer’s dried grains, palm oil cake, winery mash and so on, which are not fully utilized in livestock feeding. Most of these products are low in major nutrients and do not form properly balanced diets (Devendra, 1983). The difficulty of the use of these feed sources as fresh material for extended periods and the lack of efficient ways for their integration in feeding regimes may account for their under-utilization (Chadhokar, 1984).

Field and Plantation Crops

Banana: There are two by-products from banana cultivation that are potentially valuable feeds; these are banana rejects or wastes and banana stems. These wastes are produced in the Asian countries in significant quantities. In the Philippines banana wastes are fed directly to livestock especially when it is fed fresh (Devendra, 1985). Reject bananas have also been used as a fermentation substrate for the production of single cell protein (Sequido et al, 1979).

Banana stems are also by-products of banana cultivation which are usually discarded and allowed to rot. The stem is a valuable source of minerals which are concentrated in the pith of the stem and have been used as one of the ingredients in the Lehmann system of feeding (Devendra, 1963).

Cassava: The waste products obtainable from cassava roots are the peels which are usually discarded during the manufacture of cassava chips used for the feeding of livestock especially ruminants, the other waste product obtained from the root is cassava pulp which is produced during the manufacture of cassava flour. In India, cassava pulp was used to replace 50% of the ragi flour in the diets of layers (Pillai et al, 1968).

Maize: The residues obtained from maize are of three categories: (a) the stalk, (b) the husks, skins and trimmings and (c) the cobs. The grain is recovered from the cob by de-husking the ear. The stalk which is usually referred to as stover (Devendra, 1985) is obtained during harvesting of maize. This portion along with the husk, skin and trimmings are usually fed to ruminants. The harder portions are used for making silage or compost.

Rice: Rice production represents the most important component of agriculture in most countries in the tropics. In most of the countries of this region, the rice milling industry is advanced and is associated with important agro-based industries; this is due to the production of large amounts of important by-products: rice straw and rice husks (15-17%), broken rice (4-5%) and rice bran (6-10%). It is however doubtful if all these available by-products are effectively utilized.

For example, in Malaysia, broken rice has been used up to levels of 30, 40, and 50% , compared to a maize diet (50% inclusion) in growing pigs, no significant differences were observed in live weight gain, feed efficiency and carcass characteristics between the two groups of experimental animals. (Mellish, et al.,1973). Khajarern, et al., (1979) used 50.7% level inclusion of broken rice in broiler diets and did not observe any loss in the performance of the birds.

Rice husks also constitute another by-product of rice production. However they are not as important as rice straw or rice bran for the feeding of ruminants because of its low nutritional value (Devendra, 1985), it is however a valuable source of roughages for ruminants (White, 1965; Horton and Flynn, 1967). Rice husks can be milled into a fine powder and used as diluents of other high energy feed stuff (Richardson et al, 1958). Studies on the use of roughages as feed material have shown however that only low levels are recommended to give optimal results (Tilman, et al., 1969).

Sugarcane: The residue after juice extraction from the sugarcane plant is referred to as bagasse. It constitutes approximately 15-20% of sugarcane tops with a moisture content of about 50%. Presently this material is used mainly as a fuel in sugar factories and is also valuable as feed source for livestock such as ruminants especially in the sugar growing areas of the West Indies (Work, 1937, Davis and Kirk, 1962; Brown et al, 1959). In Mexico, replacement of maize silage with bagasse by 0, 20 and 40% did not significantly depress live weight gain, feed intake and feed efficiency (Hochstrasser, et al., 1977). The value of combined chemical and pressure treatment on bagasse has been demonstrated (Martin, et al., 1976). In an experiment, Roxas et al (1969) determined the digestibility of bagasse-based diets (40-60%) supplemented with molasses, copra meal and wheat pollard fed to sheep, cattle and caraboas, the studies revealed that the large ruminants had higher dry matter intake than sheep which lost weight. The bulky and fibrous nature of the by-product renders it a suitable feed for ruminants especially dairy cows (Randal, et al., 1967). Bagasse has also been fed intact with sugarcane excluding the outer rind in the form of comfit, a product derived in West Indies (Donefer, *et al*., 1973).

Browse Foliage

Fodder trees and shrubs have high potential values as sources of feed for domestic livestock and wildlife. They can be successfully integrated into production systems to provide additional feed resources for use in mixed diets of livestock. Numerous shrub and tree species have been investigated.

Cacti: This plant is characterized by high water use efficiency and their pads are covered with a thick epidermis. During the day, the stomata are closed, but are opened at night, this assists in reduction of water evaporation in this plant species. Cacti are multipurpose range plants which can be used to provide forage for livestock. Cacti are high in soluble carbohydrates, calcium, potassium and vitamin A, but are low in crude fiber and crude protein, they are also considered as a source of water for animals raised under harsh environments (Nefzaoui and Ben Salem, 2002). Supplementing poor roughages such as straws with cactus, increases straw intake, digestibility and increased rumen microbial activity but decreased cellulolytic activity (Ben Salem et al., 1996). Studies have shown that protein nitrogen supply improves the nutritive value of cactus-based diets fed to lambs and increases daily body weight gain (Ben Salem et al., 2002). Improvements have been recorded with an increase in the level of by-pass proteins in the diet.

Moringa oleifera: Published data (Fugile, 2001) has described moringa as a miracle tree and has been shown to have numerous uses, amongst which are the coagulant properties of the seeds. Studies (Foidl et al., 2001) have shown that it can be used as a protein meal in livestock diet as it contains approximately 60% crude protein. These studies have also shown that the leaves of this plant are edible and highly nutritious and provide approximately 25% crude protein. Total protein digestibility of these leaves is high and the leaves are free of anti-nutritive factors such as tannins, phenols and saponins. These studies have also shown that the iron content of the leaves is up to 582 mg/kg DM, the beta-carotene content is up to 400mg/kg and vitamin C content is as high as 9.2g/kg.

Gliricidia sepium: This is a tropical tree legume which grows abundantly in the rain forest zones of West Africa. Studies (Gohl, 1981; Adejumo and Ademosun, 1985) have shown that the leaves contain as much as 20-30% crude fiber. The plant grows vigorously, is drought-resistant, has good re-growth potentials and can be used to provide livestock feed all the year round (Atta-Krah and Sumberg, 1986). Recent studies (Amata, 2010) have shown that dietary treatments with varying levels of Gliricida sepium leaf meal up to 20% inclusion does not affect hematological parameters and values obtained fell within reported ranges.

Myrianthus arboreus: This is a dioceus tropical tree growing up to 15m high with spreading branches from a short stem. It is usually found in the forest and damp places, in areas with an altitude between 700-1200m. *Myrianthus arboreus* is a native of Angola, Cameroon, Congo, Cote d'Ivoire, Kenya, Sudan, Tanzania, Uganda and Nigeria. The young leaves are popularly consumed in West Africa as vegetable soup. In Delta and Edo States of Nigeria, the leaves are rated amongst the most popular indigenous vegetables. Studies on the composition of the fresh fruit pulp reveal appreciable levels of protein, calcium, iron and phosphorous and it is a good source of metabolizable energy (Okafor, 2004). Recent studies (Amata, 2010) on the nutritive value of the leaves of *Myrianthus arboreus* reveal appreciable levels of protein (18.74% DM) a value which compares favorably with protein values obtained for leafy vegetables. These studies also revealed appreciable levels of crude fiber content (11.6% DM), ash content of 16.4% DM, ether extract value of 13.1% DM and metabolizable energy values of 1333.4Kcal Kg^{-1}, which is an indication of its suitability as an energy provider in the diets of livestock. The study revealed the presence of nine amino acids in varying proportions, two of which were sulfur containing amino acids. The anti-nutritional factors present in the leaves were within acceptable ranges.

G*melina arborea*: This is a deciduous tree of medium size grows up to 40m in height and has a diameter of 60-100cm (Jensen, 1995). The leaves are simple and are more or less heart shaped and are usually 10-25cm long and 5-18cm wide. *Gmelina arborea* is commonly found in rain forests and also dry deciduous forests. The tree grows well in climates with mean annual temperatures of 21-28^{0}C (Jensen, 1995) and grows best in deep well drained base rich soils with a pH between 5.0 and 8.0. *Gmelina arborea* originated in South East Asia from Pakistan, Sri-Lanka and Myanmar. The tree has been planted in tropical African and Latin American Countries (Evans, 1982). Recent studies (Amata and Lebari, 2011) on the nutrient profile of the fresh leaves reveal appreciable levels of crude protein (14.6% DM), crude fiber (6.7%DM), ash content (1.3%DM) and ether extract (12.7%DM). Metabolizable energy values were found to be appreciable (1368 Kcal Kg^{-1}) an indication of its suitability as an energy source for livestock diets. The study revealed appreciable levels of essential amino acids and this indicates that the leaves could be a good source of protein. Recent studies (Amata and Iwelu, 2012) show the potentials of the fresh fruit pulps of *Gmelina arborea* as non-conventional feeding materials.

Terminalia catappa: This is a large deciduous tree originally from India and belongs to the family Combretacecae. Some of its common names include tropical almond, Indian almond, wild almond and Java almond. The tree grows up to 18m high with horizontal whorls of branches offering clusters of foot long obviate leaves that turn pink-red to red-yellow before being shed. It has large nutty fruits that taste like commercially grown almonds. *Terminallia catappa* requires full sun, moist and well drained soil. It is salt and drought tolerant and can be planted in frost free areas. Recent studies on the nutrient profile of the leaves (Amata and Lebari, 2010) and the seeds of *Terminalia catappa* (Amata and Nwagu, 2012) reveal the potentials of this plant as a non-conventional feed source for livestock feeding.

Dacroydes edulis: This browse plant belongs to the family Burseraceae and is commonly referred to as African pear and is a native of tropical West Africa. The tree bears edible fruits and oil seeds which are used as food and fodder. It grows mostly in the tropics and reaches up to 18m in height and exudes odiferous gummy substances from injured or excised portion of the stem (Ekpa, 1993). The fruit is red and turns blue-black when ripe with an unpleasant turpentine smell. It consists of large seeds, surrounded by a thin mesocarp. The leaves are pinnate with leaflets measuring 3-4cm by 2-3cm and the leaflets are narrowly oblong and elliptic. Recent studies on the suitability of the seed meal as partial replacement of dietary maize in poultry diets (Bratte et al., 2011) concluded that *Dacroydes edulis* seed meal had no adverse effect on semen quality of broiler breeders even at 45-60% replacement of dietary maize in the diet of broilers. Research findings on the nutrient profile of the leaves (Amata and Lebari, 2010) and seeds (Amata and Nwagu, 2012) have shown the potentials of *Dacroydes edulis* plant as a supplement or substitute for conventional livestock feed. Studies (Abdullahi and Abdullahi, 2005; Amata and Nwagu, 2012) have identified high levels of alkaloids in the seeds of *Dacroydes edulis* however it has been shown (Okai et al., 1995; Abdullahi and Abdullahi, 2005; Dei et al., 2007) that soaking or boiling in hot water of such plant materials drastically reduces the toxic effects of these anti-nutritional components.

Techniques to improve utilization of non-conventional feedstuff

A set of technologies has been investigated in Africa and Asia to improve the nutritive value of low quality feed sources. The most popular ones include ammonia treatment of cereal and rice straws and mixing of several agro-industrial-by products in the form of hard feed blocks.

Supplementation: Adequate supply of nutrients may improve the nutritive value of low quality feeds and from a practical point of view, it is believed that supplementation with grains and concentrate feeds is the only way to provide a balanced feed. However in drought conditions, the use of concentrates is usually high and this could lead to significant increases in the cost of feeding. Alternative feed sources may be used as feed for small ruminants but given the lack of definite knowledge of their nutritive value of such alternative sources; such diets given to these small ruminants are often unbalanced and may not be adapted to the physiological state of the animal. Appropriate use of several by-products and browse foliage could partially or totally replace common grains and concentrate feeds without causing any negative effects on livestock performance.

Chemical treatment: An alternative to the use of supplementary feeds is to treat the cereal crop residues by chemical treatment to improve its quality, however such a process requires additional labor and materials and this affects the flexibility of such a process. Chemicals such as ammonia gas or ammonia generated from urea under anaerobic conditions renders fiber more fragile and disrupt the bond between lignin and other digestible components in fibrous feedstuff such as straws. Ammonia treatment increases crude protein content, feed intake and digestibility of treated straws thereby improving livestock productivity. The high cost of urea and to a less extent plastic sheet cover treated straw however is a main factor limiting adoption of this method by farmers. Attempts have been made to reduce the cost of ammonia straw treatment. Studies (Ben Salem et al., 1995) have shown that mud could be used to cover urea-treated straw instead of plastic sheets.

Ensiling: Although numerous agro-industrial by-products are available in large amounts and are rich in certain nutrients, most of them are not widely used in livestock feeding; examples are tomato pulp which is high in crude protein and citrus pulp which is high in energy. Due to high moisture content of olive cake and tomato pulp for example, there is the tendency for such by-products to become rancid and moldy. Ensiling techniques can be safely used to extend the storage period of these by-products separately or combined with other by-products such as molasses or wheat bran. Hadjipanayiotou (1999) observed that olive cake preserved well as silage, judging from its aroma, color, pH and the absence of molds and replacing parts of barley hay and straw with olive cake silage in the diets of lactating ewes, goats and cows did not have negative effects on milk yield and fat-corrected milk yield. Results from studies on the incorporation of citrus pulp and wheat straw silage in lamb diets to replace oat hay and 30 commercial concentrates (Scerra et al., 2000) revealed similarities in live weight and carcass weights among the treatment groups. Lambs on silage produced carcasses with better muscular conformation and lower fatness score.

Feed block technology: Agro-industrial by-products especially those with high moisture content can be efficiently used through feed block technology. This technology (Ben Salem and Nefzaoui, 2003) provides flexibility to extension workers and farmers to choose ingredients to be included in the feed block and its use as supplements in drought and other harsh conditions. In addition, the blocks can be prepared when the ingredients' cost is low and stored for later use. These cost effective supplements are solidified mixtures of some known agro-industrial by-products such as olive cake, tomato pulp and molasses to mention a few, urea, binders such as cement and/or quicklime, minerals and vitamins. These block considered as catalytic supplements are able to enhance digestion of low quality fibrous feedstuff through balanced synchronized and fractional supply of main nutrients to the animal on poor diets. Feed blocks may also be used as vehicles for several minerals such as copper and zinc and to improve reproduction performance of small ruminants (Al-Haboby et al., 1999) and as carriers of several reagents mainly polyethylene glycol (PEG) used to deactivate tannins in fodder shrubs and trees (Ben Salem et al., 2000; Ben Salem et al., 2002). Feed blocks may also be used to provide antihelminthic medicines to control gastrointestinal parasites in browsing animals (Anindo et al., 1998) and rumen modifiers such as saponins to decrease protozoa in the rumen leading to higher efficiency of microbial protein production. Of particular interest is the possible use of feed blocks to partially or totally replace expensive concentrate feeds commonly distributed to ruminants on low quality roughages, thereby reducing feeding costs.

Deactivation of secondary compounds: It has been established (Ben Salem et al., 2002) that the nutritive value of acacia foliage is low and animals feeding on this shrub tend to lose weight. These negative effects were attributed to tannins present in the acacia shrub. Satisfactory attempts to improve the nutritive value of this shrub were obtained after feeding trials with polyethylene glycol (PEG -400) in small ruminants (Getachew et al., 2001). These authors showed that slow release of PEG in *in vitro* incubation system containing tannin-rich feed produced higher microbial protein in the rumen as compared to a one-time delivery of the same amount of PEG in the system.

Tannins in browse foliage: Tannins in forage legumes have generally been classified as anti-nutritional; however it is possible that tannins could be employed advantageously to improve production. In a recent study (Ben Salem et al., 2002b) it has been observed that acacia tannins could be advantageously used to increase rumen undegradable proteins in cactus-based diets fed to lambs.

CONCLUSION

The major reason for low levels of animal production in numerous African countries is the inadequate supply and low level of feeding due to serious shortage of feedstuffs. A distinctive gap exists between the requirements and supplies of nutrients for livestock. It is desirable that adequate feed resources should be built up. The African continent has considerable amounts of crop residues such as straws, molasses and other agro-industrial by-products. Several factors however may account for their limited use, among which is low nutritive value and difficulty in handling and using for extended periods. It is essential to increase feeds by growing more fodders, propagating agro and social forestry, improving the nutritive value of crop residues and utilizing other non-conventional feed resources. Crop residues, agro-industrial by-products and browse foliage are increasingly becoming important in their role as feed in the future as human and livestock populations expand. Special attention should be given to efficient integration of multipurpose fodder shrubs and trees as fodder bank in feeding calendars of sheep and goats under harsh climates. The involvement of farmers could provide an avenue for discussion of the appropriateness of the different technologies discussed in this paper, enabling researchers to change, modify or refine their technology to respond appropriately to practical conditions. The involvement of local extension agencies in technology development, assessment and transfer is also an important factor.

REFERENCES

[1] Adejumo, J.O. and A.A. Ademosun (**1985**) *J. Anim. Prod. Res*., 5:1-2.
[2] Abdullahi, S.A. and Abdullahi, G.M. (**2005**). *Nigerian Food Journal*, 23: ISSN 0189-72412.
[3] Al-Haboby, A.H., Salman, A.D. and Abdul Kareem, T.A. (**1969**). *Small Ruminant Res*., 34:33-40
[4] Amata, I.A. (**2010**). *International Journal of Agricultural Research* 5(8): 576-581.
[5] Amata, I.A. and T. Lebari. (**2011**) *African Journal of Biotechnology*. 10(64):14230-14233.
[6] Amata, I.A. and E.E. Iwelu. (**2012**). *International journal of Innovations in Bio-Sciences*. 2(3):126-129.
[7] Amata, I.A. and K.M. Nwagu. (**2012**). I*nternational Journal of Applied Biology and Pharmaceutical Technology*. 4(1): 200-204.
[8] Anindo, D., Toé, F., Tembely, S., Mukasa-Mugerwa, E., Lahlou-Kassi, A. and Sovani, S. (**1998**). *Small Ruminant Res.*, 27: 63-71.
[9] Attah-Krah, A.A. and Sumberg, J.E. (**1986**). *Agro-Forestry Systems*. 6: 167-178.
[10] Ben Salem, H., Nefzaoui, A., Messaoudi, A. and Ben Arif, T. (**1995**). *Ann. Zootech*., 45 (1): 119.
[11] Ben Salem, H., Nefzaoui, A., Abdouli, H. and Ørskov, E.R. (**1996**). *Anim. Sci.*, 62:293-299.
[12] Ben Salem, H., Nefzaoui, A., Ben Salem, L. and Tisserand, J.L. (**2000**). *Livestock Production Science*., 64: 51-60.
[13] Ben Salem, H., Atti, N., Priolo, A. and Nefzaoui, A. (**2002**). *Anim. Sci*., 75: 127-135.
[14] Ben Salem, H., Nefzaoui, A. and Ben Salem, L. (**2002b**). Nitrogen Supplementation improves the nutritive value of *Opuntia ficus indica f. inermis*-based diets and sheep growth. In: proceedings of the 4th International Congress on Cactus Pear and Cochineal, Nefzaoui, A. and Inglese, P. (eds), Hammamet (Tunisia), 22-28 October 2000. *Acta Horticulturae*, 581: 317-321.

[15] Ben Salem, H. and Nefzaoui, A. (**2003**). *Small Ruminant Res*., 49 (3); 275-288.
[16] Bratte, L., Amata, I.A., Omeje, S.I. and Egbunike, G.N. (**2011**). *Asian journal of Animal Sciences*, 5(1): 71-79.
[17] Brown, P.B., Damon, R, jr., d'Escrvian, T.E., Singletary, C.S. and Robertson, Col. (**1959**). 22:13-18.
[18] Chadhokar, P.A. (**1984**). Non-conventional feed resources for livestock in soil and water conservation program. Community Forestry and Soil Conservation Development Department, Ministry of Agric. FAO. Adis-Ababa, Ethiopia.
[19] Davis, G.K. and Kirk, W.G. (**1962**). *Sugar J*. 21:12-19.
[20] Dei, H.K., Rose, S.P. and Mackenzie, A.M. (**2007**). *World Poultry Science Journal*. 63(4): 611-624.
[21] Devendra, C. (**1963**). *Malays. Agric. J*. 44: 26-41.
[22] Devendra, C. (**1983**). Small farm systems combining animals with crops. Proc. 5th Wrld. Anim. Prod. Conf. 14-19th Aug. 1983, p. 173-191.
[23] Devendra, C (**1983**). Small farm systems combining crops and animals. In; Proceedings of the 5th World Conference on Animal Production. Vol.1, pp. 173-191.
[24] Devendra, C. (**1985**). Characteristics and limitations of non-conventional feedstuffs in the Asian Region. Proc. Symp. Feeding Systems of Animals in temperate areas, 2-4th May, **1985**, Seoyl, Korea, p.338-348.
[25] Donefer, E., James, L.A. and Lauria, C.K. (1973). Use of sugarcane derived feedstuff for livestock. 3rd . Wrld Conf. Anim. Prod., 3:5-27.
[26] Ekpa, O. (**1993**). *Discovery and Innovation.* 5:312-313.
[27] Evans, J. (**1982**). Plantation forestry in the tropics. Claredon Press, Oxford, UK. P.472
[28] FAO, (**1985**). FAO/APHCA Publication: Non-conventional feed resources in Asia and the pacific (2nd ed). FAO regional office for Asia and the Pacific, Bangkok, 1985.
[29] Foidl, N., Makkar, H.P.S. and Becker, K. (**2001**). Potential of *Moringa olifera* for agricultural and industry uses. In: The Miracle Tree. The Multiple Attributes of moringa, Fugile, L.G. (ed). CTA, Wageningen, The Netherlands, pp. 45-76.
[30] Fugile, L.G. (ed). (**2001**). The Miracle Tree. The multiple attributes of Moringa, CTA, Wageningen, The Netherlands.
[31] Getachew, G., Makkar, H.P.S. and Becker, K. (**2001**). *Anim. Feed Sci. Tech*., 92: 51-57.
[32] Göw, B., (**1981**). Tropical feeds; Feed information summaries and nutritive values. FAO Animal Production and Health Series, No. 12 FAO, Rome, Italy.
[33] Hadjipanayiotou, M. (**1999**). *Livest. Prod. Sci*., 59: 61-66.
[34] Hochstrasser, R., Riquelme, E. and Rincoon, R.M. (**1977**). Cane pith as a substitute of maize silage in rations for growing calves. 11th Int. Conf. of Sugarcane in Animal Production. 25-27th April, 1979, Mexico pp 17.
[35] Horton, O.H. and Flynn, C. (**1967**). Rice hulls as a fiber source in complete dairy rations. Rice J., 70:23
[36] Jensen, M. (**1995**). Trees commonly cultivated in South East Asia: An illustrated field guide: FAO Regional Office for Asia and Pacific (RAP), Bangkok, Thailand.
[37] Khajarern, J.M., Khajaren, S., Bunsiddhi, D. and Patanakulchai, V. (**1979**). An evaluation of replacement value of cassava root meal for maize, sorghum or rice by-products in broiler rations. Ann. Report. Cassava/Nutrtion Project, 1978, University of Khon Kaen, Thailand, p. 54-557.
[38] Martin, P.C., Cabello, A. and Elias, A (**1976**). *Cuban J. Agric. Sci*., 10:19-28.
[39] Mellish, K.S., Devendra, C. and Mahendranathan, T. (**1973**). *MARDI Res. Bull*., 1: 41-47.
[40] Nefzaoui, A. (**1999**). Olive Tree By-Products. ICARDA, Aleppo, Syria, 124pp.
[41] Nefzaoui, A. and Ben Salem, H. (**2002**). Forage fodder and animal nutrition. In: Cacti: Biology and Uses, Nobel, P.S. (ed). University of California Press, Berkeley, CA, USA, pp. 190-210.
[42] Okai, D.B., Topps, J.H., English, P., Tuah, A.K. and Osafo, E.L.K. (**1995**). *Ghana Journal of Biochemistry, Biotechnology and Molecular Biology*. 3: 76-82.
[43] Okafor, J.C., (**2004**). *Myrianthus arboreus*. P. Beauv. In: PROTA 2: Vegetables/Legumes, Grubben, G.J.H. and O.A. Denton (eds). PROTA Foundation, Waganingen, Netherlands.
[44] Pillai, S.C., Srinath, E.G., Mathur, M.L., Naidu, P.M.N. and Muthanna, P.G. (**1968**). *Current Sci*. 37: 603-606.
[45] Randal, P.F., Soldevila,M. and Salas, B. (**1967**). *J. Agric. Univ. Puetorico*, 51: 167-176.
[46] Richardson, E.C., Watts, A.B. and Epps, E.A. (**1958**). *Poult. Sci*., 37:1278-1283.
[47] Roxas, D.B., Perez, C.B.Jr. and Trinidad, E.E. (**1969**). *Phil. J. Anim. Sci*., 6: 33-42.
[48] Scerra, V., Caparra, P., Foti, F., Lanza, M. and Priolo, A. (**2000**). *Small Ruminant Res*., **2019**:1-6.
[49] Sequido, M.A.P., Verma, A., Cayabab and Uyenco, F.R. (**1979**). Production of microbial protein from banana fruit rejects for feed purposes. Proc. Workshop on Bioconversion of lignocellulosic and carbohydrate residue in rural communities, 11th-15th Dec. **1979**, Bali, Indonesia, pp. 21.
[50] Tillman, A.D., Fur, R.D., Hansen, K.R., Sherrod, L.B. and World, J.D. Jr. (**1969**). *J.Anim. Sci*., 29 :792-796.

[51] White, T.W. (**1965**). Rice hulls tested for beef cattle. Louisiana Agric. Expt. Sta., 8: 5-11.
[52] Work,S.H. (**1937**). *Hawaiian Agric. Expt. Sta. Ann. Rpt*., p. 77-80.
[53] Younas, M. and Yaqoob, M. (**2005**). *Livestock Research for Rural Development* : 17(2).