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Base Line Information on Nutritional Profiling Of Non-Conventional Livestock Feed Resources

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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. The shortage of feed resources for livestock and poultry feeding diverted majority of research in the field of animal nutrition to look into all possibilities to overcome this nutritional crisis. The most viable proposition could be the inclusion new NCFR in ration with suitable complete feed technology, so as to utilize the feed resources with maximum efficiency. A major gap exists between the demand and supply of concentrates and green and dry fodders for feeding livestock in the world. To overcome this shortage, it is essential to increase the availability of feed and fodder for the different productions and functions of the animals. One of the solutions is also to exploit the use NCFR in the animal feeding system. Some of the potentially available NCFR are rubber seed cake, Sal seed meal, tapioca waste, tea waste, babul seeds, slaughter house by-products, mango seed kernels, nizger seed cake, karanj cake, guar meal, Prosopis juliflora pods and cassava leaf meal, Sea buckthorn leaves, cake and pomace, and animal organic wastes (bovine and poultry excreta) etc. Many of these feed materials are low in energy, protein, minerals and contain high amounts of lignin, silica and other nutritionally incriminating substances. The main constraints to the use of non-conventional feed resources are collection, dehydration for high moisture content and detoxification processes. Processing technologies that are economic and practical are urgently required. The utilization of non-conventional feedstuffs of plant origin had been limited as a result of the presence of alkaloids, glycosides, oxalic acids, phytates, protease inhibitors, haematoglutinin, saponegin, momosine, cyanoglycosides, linamarin to mention a few despite their nutrient values and low cost implications. These anti-nutritional factors negate growth and other physiological activities at higher inclusion levels. These anti-nutritional factors need to be removed or inactivated by various procedures before the use of the ingredients in the diet.

1. INTRODUCTION

The livestock population in Ethiopia is considered to be the largest in Africa. It was reported that the country owns about 60 million cattle, 33.5 million sheep, 32.06 million goats, 1.91 million horses, 6.75 million donkeys, 0.35 million mules, 1 million camels and 60.38 millions of poultry (1). This livestock sector has been contributing considerable portion to the economy of the country both at the household and national levels and have in the past provided significant export earnings. But not to the extent it has to contribute to the development of the economy of the country. This is due to different constraints from which feed inadequacies (huge gap between demand and supply of nutrients) are reported to be all-encompassing and persistent constraints affecting the production and reproductive performance of different classes of livestock (2), (3), (4).The focus of feed resources and their utilization represents possibly the most exciting task facing planners and animal scientists in developing countries (5) which is the same catastrophe in Ethiopia. The most devastating factor diminishing of feed for animals is due to rapid increment in the expansion of arable land that reduce the grazing land which is the major source of conventional animal feeds. Due to the shortage of traditional feeds, non-conventional feeds may be the other alternative feeds.

Limited feed supply and poor quality of the available feeds are the major constraints for optimal livestock productivity in tropical and sub-tropical countries (6). These regions are characterized by irregular rainfall and thus livestock have to survive on persistent shortage of feed resources of low nutritional value for most part of the year (7). 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(8). 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.

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 byproducts 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 (9). Therefore, this paper aims to review the major non-conventional feed resources with the overall objectives listed below,

1. To highlight information on the nutritional value of various nonconventional feedstuffs on livestock
2. To review the best options of using non-conventional feeds as alternative sources of feed
3. To review the effects of ammoniation (feed processing methods) on the nutritional value of high fiber containing feed stuffs on the performance of livestock

2. LITERATURE REVIEW

2.1. Non-Conventional Feeds

A major gap exists between the demand and supply of concentrates and green and dry fodders for feeding livestock in the world. To overcome this shortage, it is essential to increase the availability of feed and fodder for the different productions and functions of the animals. One of the solutions is also to exploit the use of NCFR in the animal feeding system. Some of the potentially available NCFR are rubber seed cake, Sal seed meal, tapioca waste, tea waste, babul seeds, slaughter house byproducts, mango seed kernels, nizger seed cake, karanj cake, guar meal, Prosopis juliflora pods and cassava leaf meal, Sea buckthorn leaves, cake and pomace, and animal organic wastes (bovine and poultry excreta) etc. Many of these feed materials are low in energy, protein, minerals and contain high amounts of lignin, silica and other nutritionally incriminating substances.

The main constraints to the use of non-conventional feed resources are collection, dehydration for high moisture content and detoxification processes. Processing technologies that are economic and practical are urgently required. Some of the materials like Sal seed meal; neem seed cake, mahua seed cake, and galas seed cake are available in large quantities but due to the presence of potent toxic substances, have limited value as animal feeds. Many of the forest tree seeds contain 15-35% oil and are used for the extraction of oil, after which the cake is valuable as animal feeds. Animal organic wastes such as dung and poultry excreta are also potentially available as a part of animal feeds. During the dry periods, poor quality feeds and inadequate nutrition has been reported to be one of the most important constraints for livestock production in Ethiopia across all ecological zones. In addition, degradation of lands due to uncontrolled and excessive use of communal grazing lands of undulated topography in the highlands and erratic rainfall in semi-arid areas has further reduced the availability of feed resources (7).

Essential or indispensable amino acids (EAAs) cannot be synthesized by fish and often remain inadequate but are needed for growth and tissue development (10). Fishmeal is known to contain complete EAA profile that is needed to meet the protein requirement of most fish species. Since fishmeal is expensive as a feed ingredient, the use of non-conventional feedstuffs has been reported with good growth and better cost benefit values. The utilization of non-conventional feedstuffs of plant origin had been limited as a result of the presence of alkaloids, glycosides, oxalic acids, phytates, protease inhibitors, haematoglutinin, saponegin, momosine, cyanoglycosides, linamarin to mention a few despite their nutrient values and low cost implications (11) (12).

These anti-nutritional factors negate growth and other physiological activities at higher inclusion levels (13). NCFRs are credited for being noncompetitive in terms of human consumption, very cheap to purchase, by-products or waste products from agriculture, farm made feeds and processing industries and are able to serve as a form of waste management in enhancing good sanitation. These include all types of feedstuffs from animal (silkworm, maggot, termite, grub, earthworm, snail, tadpoles etc.), plant wastes (jack bean, cottonseed meal, soybean meal, cajanus, chaya, duckweed, maize bran, rice bran, palm kernel cake, groundnut cake, brewers waste etc.) and wastes from animal sources and processing of food for human consumption such as animal dung, offal, visceral, feathers, fish silage, bone, blood) (14) (15) (16)(17). All these can be recycled to improve their value if there are economically justifiable and technological means for converting them into useable products.

2.2 Need of Non-conventional feed resources:

There are serious shortages in animal feeds of the conventional type. The grains are required almost exclusively for human consumption. With increasing demand for livestock products as a result of rapid growth in the world economies and shrinking land area, future hopes of feeding the animals and safeguarding their food security will depend on the better utilization of unconventional feed resources which do not compete with human food. The availability of feed resources and their rational utilization for livestock represents possibly the most compelling task facing planners and animal scientists in the world. The situation is acute in numerous developing countries where chronic annual feed deficits and increasing animal populations are common, thus making the problem a continuing saga.

Thus non-conventional feeds could partly fill the gap in the feed supply, decrease competition for food between humans and animals, reduce feed cost, and contribute to self-sufficiency in nutrients from locally available feed sources. It is therefore imperative to examine for cheaper non-conventional feed resources that can improve intake and digestibility of low quality forages. Feedstuffs such as fish offal, duckweed and kitchen leftovers (i.e., potato peel, carrot peel, onion peel, and cabbage leftover), poultry litter, algae/Spirulina, Leucaena leaf, local brewery and distillery by-products, sisal waste, cactus, coffee parchment and coffee pulp are commonly used in India, and could be invaluable feed resources for small and medium size holders of livestock.

2.3 Advantages of Non-conventional feed resources

a) These are end products of production and consumption that have not been used. b) They are mainly organic and can be in a solid, slurry or liquid form. Their economic value is often very less. c) Fruit wastes such as banana rejects and pineapple pulp by comparison have sugars which are energetically very beneficial. d) The feed crops which generate valuable NCFR are excellent sources of fermentable carbohydrates eg. Cassava and sweet potato and this are an advantage to ruminants because of their ability to utilize inorganic nitrogen. e) Concerning the feeds of crop origin, the majority are bulky poor-quality cellulosic roughages with a high crude fibre and low nitrogen contents, suitable for feeding to ruminants. f) They have considerable potential as feed materials and their value can be increased if they are converted into some usable products.

2.4. Sources of non-conventional feeds

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 (18). 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. Defined in this manner the NCFR embrace a wide diversity of feeds and its nutrients contents.

A feature about feeds is that the traditional feeds of tropical origin tend to be mainly from annual crops whereas, the NCFR include commonly, a variety of feeds from perennial crops and feeds of animal and industrial origin. In this sense, the NCFR could really be more appropriately termed "new feeds", and this term is being increasingly used. Thus, the term NCFR has been frequently used to describe such new sources of feedstuffs as palm oil mill effluent and palm press fiber (oil palm by-products), single cell proteins, and feed material derived from agro-industrial by-products of plant and animal origin, poor-quality cellulosic roughages from farm residues such as stubbles, haulms, vines and from other agro-industrial by-products such as slaughterhouse by-products and those from the processing of sugar, cereal grains, citrus fruits and vegetables from the processing of food for human consumption.

2.5 By-products as feedstuffs and nutritional quality

Appropriate use of relatively inexpensive agricultural and industrial by-products is of paramount importance for profitable livestock production. However, high cost and low availability of conventional livestock feedstuffs frequently demand consideration of by-products even if efficiency of utilization is low. Efficient use of by-products relies on their chemical and physical properties, which influence production system outputs. In developing countries, grain, which forms the bulk of concentrate feeds for livestock, is both in short supply and expensive due to direct competition with human food uses.

The agro-industrial by-products like brewery waste, cashew apple waste, cashew nut shell, rice kani (broken rice), alternative cereals like ragi, bajra and green fodder like cowpea leaves, are available in plenty locally. Presently these by-products are not exploited to full extent for inclusion in the poultry feed. These by-products and fodder leaves have good nutrient composition and reported to contribute to the productive value for egg and meat with reduction in cost of production. Hence, based on chemical compositions and potential feeding value, these by-products can be incorporated in the poultry feed formulations to economize the feed cost and to increase the profit margin for the poultry farmers.

Natural pasture that is estimated to contribute to 80–90% of livestock feeds and whose quality is seasonally variable is the main source of feed in arid and semi-arid pastoral areas, while crop residues contribute up to 50% of the feed supply in mixed-farming system. Grazing lands are steadily shrinking by conversion to arable lands, and natural pastures are also restricted to areas that are marginal and have little farming potential. The reduction in natural pasture has led to overutilization and domination by undesirable forage species resulting in partial dependence on crop residues by most ruminants, which has reduced livestock productivity.

The increasing human demands for several foods (i.e. olive oil, vegetables, wine, fruit juices, etc.) led to a considerable increase of lands occupied by crops producing these feeds. Consequently, huge amounts of agro- industrial by-products are available in numerous developing countries (e.g. molasses, olive cake, winery marc, etc.), which are still not fully utilized in livestock feeding.

2.6 Agro-industrial by-products and utilization

2.6.1 Cottonseed Meal

The first record of crushing cotton seed for oil or cake (meal) is associated with the Hindus, where it is believed, the oil was used as a medication for external application. The use of cottonseed oil had earlier been documented in other parts of the world, but it was not until 1768 that extraction of oil was reported in the US. However it was not until fifteen years after the report that a greater interest was developed in this area for oil extraction and (cake) meal production for animal feed (19). Since then, improvements have been made on method of processing for oil and the meal. Presently, commercial processing of cotton is carried out by any one of the four methods; (1) hydraulic pressing; (2) screw pressing; (3) prepress solvent extraction; (4) direct solvent extract (20). The primary objective of any of these methods is to extract oil and to bind the free gossypol pigment in the meal thereby preventing the pigment (unbound gossypol) from being extracted into the oil. Cottonseed meal contains high levels of crude protein (about 40-45%). Its use in animals' diets is limited due to the presence of gossypol.

Gossypol is a yellow phenolic compound containing aromatic (benzene) rings with hydroxyl (OH) groups attached. The pigment is found primarily in cotton seeds, but has also been isolated in other parts of the plant, (roots, bark, stem, leaves and taproots) of Gossypium species. Gossypol constitutes about 0.4-1.7% of a cottonseed and is structurally shown to be (2,2'-binaphthalene)-8,8' dicarboxaldehyde - 1,1, '6,6, '7,7'-hexahydroxy 5, 5' diisopropyl 3, 3' dimethyl with a molecular weight of 518.54 and molecular formula or C30H3008 . Among all the constituents of cottonseed, the pigments have been the subject of numerous studies because of the impact it has had on the oil and the meal relative to its biochemical, physiological and economic influence on livestock feeding and nutrition. (20), indicated that the yellow gossypol derivative (C30H3008) is the major naturally occurring pigment. The gossypol pigment was first isolated by an English chemist Longmore, in 1866; and a Polish chemist (Marchlewski), crystallized the acetic acid derivative and named it gossypol, designating its genus, (Gossypium), and chemical nature, (phenol). In 1915, Withers and Carruth established that gossypol was the toxic factor in cottonseed meal ((21), (22)).

2.6.1.1 Cottonseed meal and gossypol effect on livestock.

Gossypol causes three main problems in the livestock industry: (1) tissue pathology and physiological effects. (2) binding of the epsilon amino group of lysine, resulting in a reduction in lysine availability. (3) discoloration of the egg yolk after storage of eggs from layers fed cottonseed meal. There are marked species differences in terms of response to the toxic effect of gossypol in cottonseed meal (20).

Ruminants

Ruminants are less susceptible than non-ruminants to gossypol toxicity. The mechanism is thought to involve the toxic free gossypol becoming bound to soluble proteins in the rumen and to the epsilon amino group of lysine forming a permanent bond, thereby preventing gossypol absorption. The bond is not easily broken by proteolytic enzymes secreted in the lower gut. The rumen microbes may have a role in this process (23). If the rumen detoxification process is by passed for some reason, toxicity can occur with varying toxicity signs and symptoms. Young calves with functionally undeveloped rumens are more susceptible to gossypol toxicity than adult bovines ((24),(25)).

Gossypol toxicosis in sheep can be caused by ingestion of large amounts of gossypol-containing diets or injection of gossypol acetic acid (GAA) (26). The situation in sheep production is the need for earlier weaned lambs (6-8 weeks of age) during which its rumen has three stages of development: (1) nonruminant phase, from birth to three weeks old; (2) transitional phase from three weeks to eight, and (3) a functioning ruminant phase, from eight weeks onward. In young lambs, an intake of gossypol-containing diet may result in similar toxicity symptoms, hence young sheep (lamb) of less than eight weeks can be treated as nonruminants ((24), (27), and (28)).

Poultry

Utilization of cottonseed meal in poultry diets is limited by the constituents of the meal that affect or limit its efficient utilization. These include oil, gossypol, fiber, lack of available amino acids (lysine) and total protein. Detrimental effects in poultry include reduced feed intake, efficiency of feed utilization, growth rates, fertility and or hatchability, egg production, physiological and biochemical findings as well as increased mortality rates, especially if the dietary levels of free gossypol exceed 0.04% ((29), (30), (31), (32)). Although gossypol causes discoloration of egg yolks and whites, iron salts such as ferrous sulfate (FeSO4 .7H20) inactivate gossypol, hence reducing effects on egg yolk and white yolk ((33) (34)).

Swine

Deleterious effects of gossypol have limited the efficient use of cottonseed meal in the diets of swine. Signs of gossypol toxicity in swine include labored breathing, (dyspnea), decreased growth rate and anorexia. Postmortem findings can include fluid accumulation in the peritoneal cavities, edema, and congestion in the liver and lungs (35).

2.6.1.2 Antifertility effects of cottonseed meal or gossypol

Cottonseed meal and other cottonseed products have long been used to supplement other protein sources or protein deficient diets for both human and animals. Antifertility effects were identified during the 1950s due to lack of child birth for a period of over ten years in the Habethi province of China, where cottonseed oil had been used in the people's diet. Several investigations were initiated in the 1960's on both animals and a human, leading to the discovery that gossypol is capable of inhibiting male fertility(36). About 4,000 men placed on a 20 mg gossypol pill per day for more than six months became infertile with an antifertility efficacy of 99.9%. This was evaluated by sperm examination which showed decreased motility and malformed spermatozoa, followed by gradual drop in sperm count until azoospermia was achieved. The process by which gossypol exerts its effect on spermatozoa is that the gossypol first damages the spermatids, and then with increase in dosage, spermatocytes are damaged, subsequently, the spermatids and spermatocytes are exfoliated with numerous dead spermatozoa, with dead heads and separated tails causing a decreased count in sperm and azoospermia (37). (38) Has reviewed literature on the effects on gossypol and cottonseed products on the fertility of various species of animals.

2.6.2 Sunflower oilcake

It is the residual cake remains after the expression of oil from sunflower seed and used chiefly as a livestock feed. It is a concentrated feed rich in protein and fats. In amino acid content and biochemical value oil cake proteins are superior to those of cereals; they contain more lysine, methionine, cystine, and tryptophan. Soybean oil cake is rich in amino acid lysine. The calcium and phosphorus contents are also higher. Like cereal feeds, oil cakes are poor in carotene but rich in vitamins of the B complex. Sunflower oil cake (SOC) is deficient in amino acid lysine but rich in sulphur containing amino acid methionine.

Table 1 chemical composition of sunflower oilcake

Chemical Constituents	% DM basis
Dry matter	98.60
Crude protein	26.95
Ether extract	0.39
Crude fibre	23.89
Total ash	6.54
Acid insoluble ash	1.20

Sources: Ilian and Salman, 1986; Khan and Bhatti, 2001; Rasool et al., 1999;Swain et al., 2011;Wisman, 1964

2.6.3 Rice kani

Rice (Oryza sativa) is a staple food of most of the Indian states including Goa. Rice is a staple crop in tropical cereal crop in Asia, accounts nearly 90 % of the World's total production of 480 million tones. During the milling of rough rice or paddy, several by-products become available and include polished rice (50-60 %), broken rice (1-17 %), polishings (2-3 %), bran (6-8 %) and hulls (20 %). Rice kani (broken rice) a by-product obtained through milling of rough rice or paddy is a potential unconventional energy source for poultry feeding. Therefore, there is tremendous scope for using rice kani as a substitute for high energy feed ingredient maize in poultry feed in order to reduce the feed cost as well as the competition with human beings for conventional energy source i.e. maize. Another additional advantage is that rice kani is not associated with aflatoxin which poses threat to the survivability of poultry and other livestock. The chemical composition of rice kani varies as per the sources from where it is collected, processing conditions and storage period. The range values for the chemical constituents of rice kani are given below in tabular form (Table 3).

Table 2 Chemical compositions of rice kani

Attributes	% DM basis
Dry matter (fresh basis)	87.90-95.50
Crude protein	7.19-11.41
Ether extract	1.4-1.5
Crude fibre	0.7-2.52
Total ash	0.3-3.30

Sources: Rama Rao et al., 2000; Swain et al.(2005; 2006) Rice

2.6.4 Brewers' Dried Grains

Brewer's dried grain is a valuable by-product of brewery which has a potential to be used as supplementary feed for livestock and poultry. It is a safe feed when it is used as fresh or properly dried form. These materials are considered to be good sources of un-degradable protein, energy and water-soluble vitamins. They have been used in feeding of both ruminant and monogastric animals (monogastrics using predominantly the dried forms). Brewer's grain is the material that remains after grains have been fermented during the beer making process. These materials can be fed as wet brewer's grains or dried brewer's grains. Brewers' dried grains (BDG) is a by-product of barley malt, corn or rice that is treated to remove most of the readily soluble carbohydrates, protein, fibre, linoleic acid, vitamins and minerals. Some breweries dry the brewer's grains and sell it as dried brewer's grains, while others sell it as wet brewer's grains. Both types have similar feeding characteristics if the wet brewer's grains are fed shortly after it is produced. Fermented local and industrial by-products of brewing have been used as non-conventional feedstuffs in broiler rations (41) mainly as protein and energy supplements (41). Brewery wastes are available in plenty from the local breweries which can be a potential feed ingredient to economize the poultry production.

The annual availability of brewers' grains is about 6000 metric tons in Goa(42). Brewery by-products like brewery waste grains and yeast's are worthy of consideration as potential non-conventional feeds to promote use of locally available feed ingredients. Since the BDG is rich in fibre, addition of fibre degrading enzyme may be useful in improving its feed value.

Chemical composition of BDG Brewery waste collected from the local breweries has to be sun dried before inclusion in the poultry feed. Brewery waste when collected from the brewery contains about 75 % moisture which is a major constraint for storing and because of high moisture content it is not possible to feed poultry as it is and need complete drying without much loss of nutrients. After complete drying, the brewery waste is designated as brewers' dried grains (BDG). The nutritional content of the material may vary from plant to plant and depending upon the type of grain used (barley, wheat, corn, etc.) in the initial brewing process as well as proportions being fermented and fermentative process being used. The range values for different chemical constituents of BDG are given here below

Table 3. Chemical constituents of BDG

Chemical Constituents	Per cent Composition
Dry matter	90.10-93.00
Crude protein	11.00-30.89
Ether extract	7.00-11.05
Crude fibre	9.55-20.00
Total ash	3.09-11.04
Acid insoluble ash	1.37-1.96
Calcium	0.28-0.60
Total Phosphorous	0.43-1.00

Sources: Anonymous (2012); Fasuyi, 2005; Ironkwe and Bamgbose, 2012; Isikwenu, 2011; Swain et al. (2005a)

2.7 The Poultry hatchery waste

(PHW) is the product left over in the poultry hatchery after the hatching process is completed. Poultry hatchery waste is primarily composed of dead chicks, infertile whole eggs and shells from hatched eggs (39). This material is usually incinerated, rendered, or taken to sanitary landfills and used for composting. Each of these disposal methods has particular regulatory or operational requirements or economic characteristics that may enhance or limit its use within a particular farm. Since the moisture content of the fresh hatchery waste is high it makes the disposal and incineration costly to the producer and it may be unsafe environmentally (40). Chemical composition of processed poultry hatchery waste is given in table below

Table 4 chemical composition of processed poultry hatchery waste

Chemical composition	%composition
Crude protein	22.8-44.25
Ether extract	14.40-30.00
Crude fiber	0.90-8.06
Total ash	14.00-40.00
Calcium	7.26-22.60
Total phosphorous	0.39-0.84

Sources: Ilian and Salman, 1986; Khan and Bhatti, 2001; Rasool et al., 1999;Swain et al., 2011;Wisman, 1964

3. CHARACTERISTICS OF NON-CONVENTIONAL FEEDS

According to reports (67), non-conventional feed resources like conventional feed resources have several characteristics worthy of note. – They are the end products of production processes and consumption that have not been used, recycled or salvaged. – They are mostly of organic origin and can be obtained either in a solid, slurry or liquid form. – 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. – 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. – Fruit wastes such as banana rejects and pineapple pulp by comparison have sugars which are energetically beneficial. – 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. – 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. – 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.– Substantial information is required on chemical composition, nutritive value, the presence of anti-nutritional components and value in feeding systems.

3.1. Anti- nutritional factors

One major constraint in the use of non-conventional feedstuffs is the anti-nutritional factors contained in them. Anti-nutritional factors may be defined as the chemical constituent of a feedstuff, which interferes in the normal digestion, absorption and metabolism of feeds, some of which may have deleterious effects on the animal's digestive system. Some inherent chemical constituents present in different kinds of feedstuffs interfere in the optimum utilization of nutrients and some are also toxic in high concentrations. Although anti-nutritional factors are present in many conventional feeds, these are more common in most of the non-conventional feeds (68).

These anti-nutritional factors need to be removed or inactivated by various procedures before the use of the ingredients in the diet. Many seeds, which were once used in traditional human and animal diets, have now fallen into disuse as agricultural and nutritional needs are re-assessed (69). Seeds often contain factors such as lectins, which are deleterious or toxic to animal or man (8). Seed lectins present major problems as they are resistant to heat treatment and some seeds such as kidney bean, have to be heated for several hours at temperatures above 80ºC or boiled for 10-20 minutes to ensure the elimination of their lectin activity. Great caution should therefore be taken in the use of these seeds as dietary materials. This is particularly important since recent studies suggest that long-term exposure to relatively low levels of some anti-nutritional or toxic factors may have deleterious effects on body metabolism (70).

4. FEED PROCESSING METHODS

There is an abundance of by-products and other non-conventional feedstuffs in the world that can be used as alternative sources of energy and protein feedstuff for livestock production, but often the techniques for making them more profitable for animal feeding systems are unknown or too difficult to implement for efficient livestock production. As a result, millions of tons of potentially valuable feed are either discarded or underutilized on annual basis, and in many instances, they have become environmental or pollution problems (55). As a result of economic and ecological pressures on the environment, the need for efficient disposal of such products has become of paramount importance. A possible effective disposal method is by way of converting these products of various sources (agricultural by products, forestry products, animal wastes, municipal refuse and crop residues) into energy sources for livestock feeds (56). Such sources can be effectively converted into livestock feeds through different feed processing methods. One such method is ammoniation; others may include hydrolysis, composting, dehydration, cooking, grinding and extrusion.

4.1 Ammoniation

Ammoniation is one of the feed processing methods that can be employed in treatment of fibrous feedstuff, crop residues, and other types of by-products to improve their utilization in livestock feeding. It was first studied in Germany many years ago after a marked improvement was achieved by treatment of straw with caustic soda (NaOH) (57). Ammoniation can be accomplished by either the use of ammonia hydroxide (NH3OH) or gaseous ammonia, both of which are effective in dissolving lignin, solubilizing hemicellulose, causing swelling of cellulose and providing supplemental nitrogen that can utilized by microbes for protein synthesis (57).

Ammonia (NH3) is a colorless gas with penetrating odor under standard conditions, and has a molecular weight of 17.03. Under laboratory conditions ammonia may be formed as the product of a number of chemical reactions which may include the following:

1. Ammonia salts with a strong base
2. Hydrolysis of urea
3. Nitrogen with hydrogen in the presence of a catalyst(58).

Although urea can be used as a source of ammonia for treatment of straw, it may be less effective than anhydrous ammonia because of the formation of a carbonate which decreases the Ph of the straw, hence reducing the alkalinity effect of the conformational changes in fiber. Ammonia can also be generated from other nitrogenous materials such as poultry manure, and human and animal urine. The use of the latter has been researched in Bangladesh; however, they are relatively new techniques currently being developed (59).

The beneficial effects of treating straw with ammonia under different conditions have been reviewed (57). It was also reported that ammoniation of straw increased crude protein, cell wall constituents, rumen ammonia and dry matter. They also indicated that ammoniation improved feed intake and dry matter digestibility. Dry matter intake, daily gain, and feed to gain ratio were improved as a result of treating low quality forage (limpograss and straw) with ammonia(60).

They also indicated that the apparent digestion coefficients of organic matter, neutral detergent fiber, acid detergent fiber and hemicellulose were improved, and concluded that ammoniation could provide an opportunity for improving the feeding value of low quality forages by providing an option to the traditional winter feeding programs. Other beneficial effects of ammoniating low quality forages and by-products on beef cattle and buffalo calves have been reported (61). However, although the digestibility of organic matter, crude protein and feed intake were improved as a result of treating corn straw with urea, weight gain was not influenced.

Treating wheat straw with anhydrous ammonia and ammonium hydroxide (NH4OH) improved utilization of nutrients such as dry matter, organic matter, and acid detergent fiber in sheep(62). Lambs fed ammoniated wheat straw consumed 34% more, and the nutrient digestibility, ruminal Ph and plasma urea concentration were higher when compared to those fed untreated wheat straw(63).

Ammoniation of sweet clover hay increased the nitrogen content and reduced dicourmarol levels and prevented the bleeding disease associated with sweet clover hay when fed to livestock ammoniation of endophyte-infected tall fescue hay reduced its toxicity to steers. They concluded that ammoniation may be a practical solution to some of the fescue related economic problems in cattle(64).

The toxic constituents of plants have different types of biological impact on different species of livestock. Pyrrolizidine alkaloids (PA's), found in plants like tansy ragwort, (Senecio jacobaea), Crotalaria (Crotalaria spectabilis), tall fescue (Festuca arundinacea) and various other species (Heliotropium, Echium and Amsinckia) are usually bitter in taste and function primarily as the chemical defense mechanism of plants. The PA's are not poisonous until metabolized by liver tissue to hepatoxic metabolites (pyrroles) causing irreversible liver damage. The PA's are hepatoxic to many animals and are responsible for losses of large numbers of livestock throughout the world (43).

Feeding chicks and pigs varying levels of crotalaria seeds caused decreased weight gain and high rate of mortality(65). Crotalaria is not only hepatoxic, it can also damage pulmonary, renal organs and cause fetal death and malformations in animals. Feeding tansy ragwort to lactating and kid goats resulted in mortality with obvious signs of alkaloid toxicosis. indicated that cattle and horses are more susceptible than goats, sheep and other non-ruminant herbivores (rabbits, gerbils, guinea pigs,and hamsters) to alkaloid toxicosis(43).

The toxicity of tall fescue is due to the infection of the plant by the endophytic fungus (Epichlore typhia) which upon parental administration or ingestion can result in symptoms of convulsion, muscular incoordination, increased pulse and respiration rates, mild photosensitization and coma.

The ergot peptide alkaloids (ergovaline) produced by the endophyte in tall fescue also causes fescue toxicosis, causing decreased prolactin, increased body temperature, and powerful vasoconstrictive effects. The tall fescue alkaloids can also cause prolonged gestation, thickened placentas, large weak foals, dystocia, agalactia in pregnant mares, neurohormonal imbalances of prolactin and melatonin, restricted blood flow to internal organs, aberrant reproduction, decreased growth, slow maturation and a general decrease in livestock performance particularly cattle and sheep (43).

Apart from the major oil seeds like soybean and cottonseed meals which are traditionally used as protein sources in animal feeds, there are also many others that could as well be utilized for the same purpose. Some of these are in the brassica families which include cabbage, brussels sprouts, kohlrabi, kale, meadow foam, rapeseed, broccoli, radish, mustard and turnips. The brassica family plants are known to contain glucosinolates (glycosides of B-D- thioglucose) that yield isothiocyanates, nitrile, and thiocyanates on hydrolysis by an enzyme system producing varying adverse effects on livestock consuming them. The major effects of glucosinolates products in animal production include goiter (enlarged thyroid gland), decreased feed intake, liver and kidney lesions, and poor performance in animals consuming them (43).

However, it has been reported that the deleterious effects of glucosinolate can be lowered by ammoniation. Canola seeds containing high levels of glucosinolates, treated with lime or ammonia, resulted in a lowered tainting potential by reducing the progoitrin, soluble tannin, sinapine contents and improved feed intake in pigs, but the treatment effects were not sufficient to prevent the trimethylamine effects on eggs(66). Another glucosinolate containing seed, meadowfoam has been evaluated as a feed for nonruminants, rabbits and chickens, and a satisfactory performance observed in lambs that were fed raw meadowfoam. (43) Indicated that up to 25% of meadowfoam could be fed to beef cattle without adverse effects on performance. The effects of other classes of toxicant containing seeds and forages like kohlrabi, whole cottonseed, vetch seeds, leucaena leaves, pinto and kidney beans, bracken fern and raw soybean on the performance of livestock have been documented ((43); (66)). It is clear that some of these toxic containing forages and seeds cannot be effectively utilized for livestock production without processing to achieve good performance.

The purposes of processing any feedstuff and by-product for animal feeding are mainly to eliminate their negative effects, hence bringing about improvement in digestibility, palatability, acceptability as well as alteration of particle size, extension of shelf life, increase in nutrient make up, and detoxification of toxic constituents.

4.2 Feed additives

Feed additives are defined as non-nutritive substances that can be added to feeds to improve the efficiency of feed utilization, feed acceptance, health and metabolism of the animal in one way or the other. There are many different types feed additives, however (43) classified feed additives into four broad classes based on either their principal biological or economic effects:

I. Additives that influence feed stability of feed manufacturing and feed properties.
II. Additives that modify growth, feed efficiency, metabolism and Performance
III Additives that modify animal health.
IV. Additives that modify consumer acceptance.

It was stated that another class of additive is that which is used to potentiate the disease-curing effects of antibiotics(44). Certain naturally occurring substances of plant origin like pectins, tannins, polysaccharides, cellulose, and beta-glucans are sometimes found in feedstuffs that nonruminant animals cannot digest, because they do not synthesize the required enzymes. However, commercially produced enzymes such as cellulases and beta-glucanase are used to aid digestion in nonruminants fed feedstuffs containing such substances as barley, triticale and rye.

Barley

Barley (Hordeum vulgare) is widely grown in the northern areas of North America (US and Canada), Europe, China, and the Soviet Union. It ranks fourth among the grains of the world after corn, wheat and rice, and it is also a source of energy used as a livestock as a feedstuff. Although barley is lower in digestible energy than corn and sorghum, it is higher in protein content and quality than corn. Its lower energy value is associated with its high fiber, lower starch and the high contents of poorly digested water-soluble carbohydrates called B-glucans ((45), (46)).

Beta-glucans are a part of the hemicellulose component of the plant cell structure that contain a polymerized B-glucose linked together by a chemical bond known as (1-->3)(1-->4) B-D-glucan. They are viscous, hygroscopic, gummy and are different from those found in starch (a-->1-->4 and a-1>6). The hygroscopic and gummy material causes wet and sticky feces and is responsible for wet litter problems in poultry. Glucans can also impede nutrient absorption resulting in plugging of the vent, particularly in chicks (pasty vents). The viscous content is responsible for preventing the formation of micelles, thus inhibiting the absorption of fat and other nutrients. On the average, some varieties of barley, particularly those grown in the Pacific Northwest, are known to contain up to 1.5 8% B-D glucan ((47), (48)).

The deleterious effects of the B-glucan content of barley can be overcome either by soaking or steeping in water, and by additions of commercially prepared enzymes (B-glucanase) to diets containing the grains. Soaking or steeping is believed to activate the B-glucanase enzyme already present in barley seeds, hence reducing the glucan effects. The commercially prepared enzyme (B-glucanase) and other complex carbohydrate digesting enzymes aid nonruminant animals in digestion of the grains and improve the utilization of Beta glucan containing diets ((46);(43);(48)).

4.3 Utilization of barley in poultry and turkeys

It was indicated that when B- glucanase was added to barley, it resulted in the cleavage of the B-glucan chain and reduction of the viscosity effect, thereby eliminating the encapsulating effect of the B-glucan and exposing the intracellular starch and protein to the endogenous enzymes for proper digestion (48). Inclusion of enzyme preparation (B glucanase) in the diets of chickens containing barley and rye resulted in improved body weight gain, feed intake, feed efficiency and energy digestibility (46). Enzyme supplementation can also reduce the incidence of pasted vent (49) indicated that apart from improvement in general performance and reduction in fecal moisture, enzyme supplementation also resulted in improved cage cleanliness. (50) Indicated that addition of enzyme increased fat and starch absorption in chicks fed diets containing hull-less barley.

Layers have a lower energy requirement than broilers, so a lower energy feedstuff like barley seems to be a more suitable ingredient for layers than for broilers. However, it has been suggested that one of the periods of concern in feeding barley to layers is between the ages of 20-40 weeks. During this time the layers have higher energy needs and begin to increase their feed consumption to meet both egg production and body tissues demands, but cannot adequately increase the consumption of low energy density feedstuffs. Another problem of feeding barley containing diets to layers during this time is that it can increase the high moisture content of the excreta resulting in dirty eggs(48).

However, (51) reported that feeding layers of 20-36 weeks of age on varying levels of barley, (17, 33, 50, 67, 83 and 100%) did not affect egg production and egg weights. However, following a reduction of the metabolizable energy, crude protein, lysine and methionine in the diets of the same layers at 36-64 weeks of age, egg production, egg weights and body weights were significantly decreased.

Supplementation of hull-less barley with 13-glucanase significantly improved weight gains, feed conversion, passage rate and fat digestibility in 0 - 4 weeks old short comb white leghorn cockerels; but at 4-6 weeks of age, there was no significant difference in all the parameters evaluated with or without enzyme supplementation (52). The general performance was more related to age than treatment. (47) Evaluated the use of enzyme supplementation in adult roosters fed barley-containing diets, and reported that enzyme supplementation increased the overall energy value of the barley grains by 3%, but the general performance was not affected by supplementation.

Rye

Rye (Secale cereale L) is believed to have originated from south western Asia. It is a hardy plant and has the ability to grow in sandy soils of low fertility; hence it is grown in areas not generally suitable for growing other cereals. Rye grain is used for making bread, and can also be used as a livestock feed. The green plant is often used for livestock forage. The protein value of rye seeds (6.5% 14.5%) compares with that of other grains, and is considered to be superior to that of wheat and most other cereals in biological value. However, the availability of the protein is reduced due to the presence of trypsin and chymotrypsin inhibitors and some constituents like alkyl resorcinols, pectins, pentosans, water soluble glucan, which are also known to limit its efficient utilization in animal feeding ((53); (43)). Utilization of rye in poultry As in barley, beneficial effects of enzyme supplementation of rye have been reported. (54) Fed varying levels of ground rye grain (0, 5, 10, 15, 50 and 25 %) to layers and reported that egg production and feed efficiency were lower in diets containing higher levels of rye, but other performance parameters like egg specific gravity, egg weight and haugh unit were not affected as a result of dietary treatments.

It was concluded that up to 25% rye can be included in the diets of layers without any adverse effects on specific gravity, egg weight and / or haugh unit values. Diets containing more than 40% rye are known to cause depression in egg production.(46) indicated that enzyme supplementation of rye, barley and wheat-containing diets in layers diminished the high viscosity of the grains and resulted in improvement of weight gain, egg production, starch digestibility and sticky dropping incidence.

5. CONCLUSION AND RECOMMENDATION

The main reason for the poor animal production is the inadequate supply and low level of feeding due to serious shortage of feedstuffs. A major gap exists between the requirements and supplies of nutrients for feeding of animal, the nonconventional feeds could partly fill this gap. More information is required on chemical composition, nutritive value and their utilization. Farmers are not aware of the nutritive value of some feed sources and the way for their efficient integration in livestock feeding. The involvement of local extension agencies in technology development for efficient use of NCFR, assessment and transfer is equally important. Several factors may account for their limited use, among which is their low nutritive value, Seasonal availability, high cost of handling and transportation from the production site to the farm, presence of anti-nutritional factors. 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 NCFRs.

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. The shortage of feed resources for livestock and poultry feeding diverted majority of research in the field of animal nutrition to look into all possibilities to overcome this nutritional crisis. The most viable proposition could be the inclusion new NCFR in ration with suitable complete feed technology, so as to utilize the feed resources with maximum efficiency. A major gap exists between the demand and supply of concentrates and green and dry fodders for feeding livestock in the world.

To overcome this shortage, it is essential to increase the availability of feed and fodder for the different productions and functions of the animals. One of the solutions is also to exploit the use NCFR in the animal feeding system. Some of the potentially available NCFR are rubber seed cake, Sal seed meal, tapioca waste, tea waste, babul seeds, slaughter house byproducts, mango seed kernels, nizger seed cake, karanj cake, guar meal, Prosopis juliflora pods and cassava leaf meal, Sea buckthorn leaves, cake and pomace, and animal organic wastes (bovine and poultry excreta) etc. Many of these feed materials are low in energy, protein, minerals and contain high amounts of lignin, silica and other nutritionally incriminating substances.

The main constraints to the use of non-conventional feed resources are collection, dehydration for high moisture content and detoxification processes. Processing technologies that are economic and practical are urgently required. The utilization of non-conventional feedstuffs of plant origin had been limited as a result of the presence of alkaloids, glycosides, oxalic acids, phytates, protease inhibitors, haematoglutinin, saponegin, momosine, cyanoglycosides, linamarin to mention a few despite their nutrient values and low cost implications. These anti-nutritional factors negate growth and other physiological activities at higher inclusion levels. These anti-nutritional factors need to be removed or inactivated by various procedures before the use of the ingredients in the diet. Great caution should therefore be taken in the use of these seeds as dietary materials. This is particularly important since recent studies suggest that long-term exposure to relatively low levels of some anti-nutritional or toxic factors may have deleterious effects on body metabolism.

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