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Important Anti-Nutritional Substances and Inherent Toxicants of Feeds

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Abstract
Review was carried out on important ant- nutritional factors and toxins in animal feed, their effect on animals and possible mechanisms to reduce toxicity. The major anti- nutrients found in plant protein sources are saponins, cyanogenic glycosides, tannins, phytic acid, oxalates, protease inhibitors, chlorogenic acid and amylase inhibitors. Anti-nutritional factors are compounds which reduce the nutrient utilization and/or feed intake of plants or plant products used as animal feeds. Numerous Anti-nutritional factors (ANFs) in forages can cause toxicity in livestock. Some of these toxins are produced by the grasses, legumes and other forages. The tannin-protein complexes are astringent and adversely affect feed intake and cause negative animal responses. Saponins can affect animal performance and metabolism through erythrocyte haemolysis, reduction of blood and liver cholesterol, depression of growth rate, bloat (ruminants), inhibition of smooth muscle activity, enzyme inhibition and reduction in nutrient absorption. Phytic acid forms protein and mineral-phytic acid complexes and reduces protein and mineral bioavailability, inhibits the action of gastrointestinal tyrosinase, trypsin, pepsin, lipase and amylase. Oxalic acid on the other hand binds calcium and forms calcium oxalate which adversely affects the absorption and utilization of calcium in the animal body. The positive effect of tannin in animal feeding includes; increased efficiency of protein utilization, reduction of parasite burden, reduction of proteolysis during ensilage, bloat prevention, increase quality of animal products, reduction of emission into the environment and defaunate rumen. Saponins have shown a variety activities such antitumor, cholesterol lowering, immune potentiating, anticancer, antioxidants. A number of methods can be employed to reduce the toxic effects of antinutrients in animal feed.

1. INTRODUCTION

Anti-nutrients or anti-nutritional factors may be defined as those substances generated in natural feedstuffs by the normal metabolism of species and by different mechanisms (for example inactivation of some nutrients, diminution of the digestive process or metabolic utilization of feed) which exerts effect contrary to optimum nutrition (Cheeke and Shull, 1985). Anti-nutritonal factors are substances which either by themselves or through their metabolic products, interfere with feed utilization and affect the health and production of animal or which act to reduce nutrient intake, digestion, absorption and utilization and may produce other adverse effects(Akande et al., 2010). There is a wide distribution of biologically-active constituents throughout the plant kingdom, particularly in plants used as animal feeding stuff and in human nutrition (Igile, 1996). Many plant components and seeds of legumes and other plant sources contain in their raw state wide varieties of antinutrients which are potentially toxic (D'Mello, 2000). The knowledge that these compounds elicit both toxic and advantageous biological responses has given rise to several investigations in recent times as to their possible physiological implications in various biological systems (Igile, 1996). Some of these chemicals are known as ''secondary metabolites'' and they have been shown to be highly biologically active and Most of these secondary metabolites elicit very harmful biological responses, while some are widely applied in nutrition and as pharmacologically-active agents (Soetan, 2008).

The objectives of this paper were

- ✓ To describe different anti-nutritional substances and toxicants of animal feed and mechanism of toxicity and impacts on animals
- ✓ To explain the methods used to determine anti-nutritional substances and ways of removing/reducing them from feed sources

2. COMMON ANTI-NUTRITIONAL SUBSTANCES AND INHERENT TOXICANTS OF FEEDS AND FORAGE

Anti-nutritional factors are a chemical compounds synthesized in natural food and / or feedstuffs by the normal metabolism of species. These anti-nutritional factors are also known as 'secondary metabolites' in plants and they have been shown to be highly biologically active (Habtamu and Nigussie, 2014). Anti-nutritional factors (ANF) are compounds which reduce the nutrient utilization and/or food intake of plants or plant products used as human foods or animal feeds and they play a vital role in determining the use of plants for humans and animals (Soetan K. O. and Oyewole , 2009). The toxicity due to the consumption of various forages is very common among the farm animals. The anti-nutritional factors present in the forages are mainly responsible for this

(*Smitha Patel et al., 2013)*. Anti-nutritional factors may be divided into two major categories. They are: (1). Proteins (such as lectins and protease inhibitors) which are sensitive to normal processing temperatures. (2). Other substances which are stable or resistant to these temperatures and which include, among many others, polyphenolic compounds (mainly condensed tannins), non-protein amino acids and galactomannan gums (Osagie,1998). The major ones includes: toxic amino acids, saponins, cyanogenic glycosides, tannins, phytic acid, gossypol, oxalates, goitrogens, lectins (phytohaemagglutinins), protease inhibitors, chlorogenic acid and amylase inhibitors(Akande et al., 2010). More often than not, a single plant may contain two or more toxic compounds, generally drawn from the two categories, which add to the difficulties of detoxification. According to Aletor (1993), there are several anti-nutritional factors that are very significant in plants used for human foods and animal feeds and some most common ones with their mechanism of toxicity and impact on animal health and productivity are discussed hereunder.

2.1. Tannins

Tannin is an astringent, bitter plant polyphenolic compound that either binds or precipitates proteins and various other organic compounds including amino acids and alkaloids. Tannins are the most widely occurring anti-nutritional factors found in plants. These compounds are present in numerous tree and shrub foliages, seeds and agro-industrial by-products (Dube *et al.,* 2004). Tannins have a property of binding to protein to form reversible and irreversible complexes due to the existence of a number of phenolic hydroxyl groups (Patra and Saxena, 2010). Tannins are water soluble phenolic compounds with a molecular weight greater than 500 and hydrolysable tannins and condensed tannins are two different groups of these compounds(*Smitha Patel. et al.,2013).* The two types differ in their nutritional and toxic effects. The condensed tannins have more profound digestibility-reducing effect than hydrolysable tannins, whereas, the latter may cause varied toxic manifestations due to hydrolysis in rumen (Akande et al., 2010).

Tannins are heat stable and they decreased protein digestibility in animals and humans, probably by either making protein partially unavailable or inhibiting digestive enzymes and increasing fecal nitrogen. Tannins are known to be present in food products and to inhibit the activities of trypsin, chemotrypsin, amylase and lipase, decrease the protein quality of foods and interfere with dietary iron absorption. Tannins are known to be responsible for decreased feed intake, growth rate, feed efficiency and protein digestibility in experimental animals. If tannin concentration in the diet becomes too high, microbial enzyme activities including cellulose and intestinal digestion may be depressed. Tannins also form insoluble complexes with proteins and the tannin-protein complexes may be responsible for the anti-nutritional effects of tannin containing foods (Habtamu and Nigussie, 2014).

2.2. Saponins

Saponins are secondary compounds that are generally known as non-volatile, surface active which are widely distributed in nature, occurring primarily in the plant kingdom. They are structurally diverse molecules and consist of non polar aglycones coupled with one or more monosaccharide moieties. This combination of polar and non-polar structural elements in their molecules explains their soap-like behavior in aqueous solutions. The structural complexity of saponins results in a number of physical, chemical, and biological properties, which include sweetness and bitterness, foaming and emulsifying , pharmacological and medicinal, haemolytic properties, as well as antimicrobial, insecticidal activities (Habtamu and Ngusse, 2014). Saponins reduce the uptake of certain nutrients including glucose and cholesterol at the gut through intra-lumenal physicochemical interaction. Hence, it has been reported to have hypo cholesterolemic effects (Umaru *et al.,* 2007). In chickens saponnin have been reported to reduce growth, feed efficiency and interfere the absorption of dietary lipids and vitamins (A & E) (Jenkins and Atwal,1994). Saponins are among several plant compounds which have beneficial effects. Among the various biological effects of saponins are antibacterial and antiprotozoal (Avato et al., 2006**).**

2.3. Cyanogens

Cyanogens are glycosides of a sugar or sugars and cyanide containing aglycone. It can be hydrolysed to release HCN by enzymes that are found in the cytosol. Damage to the plant occurs when the enzymes and glycoside form HCN. The hydrolytic reaction can take place in the rumen by microbial activity. Hence, ruminants are susceptible to CN toxicity than non- ruminants (*Smitha et al.,2013*). The HCN is absorbed and is rapidly detoxified in the liver by the enzyme rhodanese which converts CN to thiocyanate (SCN). Excess cyanide ion inhibits the cytochrome oxidase. This stops ATP formation, tissues suffer energy deprivation and death follows rapidly. The lethal dose of HCN for cattle and sheep is 2.0-4.0 mg per kg body weight (Sarah robson, 2007).

2.4. Oxalate

Strong bonds are formed between oxalic acid, and various other minerals, such as Calcium, Magnesium, Sodium, and Potassium. This chemical combination results in the formation of oxalate salts. Oxalate is an anti-nutrient which under normal conditions is confined to separate compartments. However, when it is processed and/or digested, it comes into contact with the nutrients in the gastrointestinal tract. When released, oxalic acid binds with nutrients, rendering them inaccessible to the body. If feed with excessive amounts of oxalic acid is consumed regularly, nutritional deficiencies are likely to occur, as well as severe irritation to the lining of the gut. In ruminants oxalic acid is of only minor significance as an anti-nutritive factor since ruminal microflora can readily metabolize soluble oxalates (Habtamu and nigusse, 2014). Various tropical grasses contain soluble oxalates in sufficient concentration to induce calcium deficiency in grazing animals. These include buffel grass (Cenchrus ciliaris), pangola grass (Digitaria decumbens), setaria (Setaria sphacelata) and kikuyugrass (Pennisetum clandestinum). Oxalates react with calcium to produce insoluble calcium oxalate, reducing calcium absorption. This leads to a disturbance in the absorbed calcium: phosphorus ratio, resulting in mobilization of bone mineral to alleviate the hypocalcemia. Prolonged mobilization of bone mineral results in nutritional secondary hyperparathyroidism or osteodystrophy fibrosa (Rahman and Kawamura, 2011). Cattle and sheep are less affected because of degradation of oxalate in the rumen. However, cattle mortalities from oxalate poisoning due to acute hypocalcemia have occurred on setaria pastures and sheep have been poisoned while grazing buffel grass. Levels of 0.5 per cent or more soluble oxalate in forage grasses may induce nutritional hyperparathyroidism in horses. Levels of 2 per cent or more soluble oxalate can lead to acute toxicosis in ruminants. The oxalate content of grasses is highest under conditions of rapid growth with concentrations as high as 6 per cent or more of dry weight (Cheeke, 1995).Young plants contain more oxalate than older plants (Jones and Ford, 1972). During early stages of growth, there is a rapid rise in oxalate content followed by a decline in oxalate levels as the plant matures (Davis, 1981). Rahman et al. (2009) observed that the oxalate content of napier grass can be manipulated by varying the harvesting interval, and that oxalate content declined as the harvest interval increased(Smitha *et al*., 2013).

2.5. Nitrates

Nitrate toxicity of cattle was noted as early as 1895 with corn-stalk poisoning. However, nitrate was not recognized as the principle toxicant during that period. In the late 1930s, after an outbreak of oat-hay poisoning in the high plains region, an indictment of nitrate was finally made (Launchbaugh, 2001). Some of the fodder crops such as sudan grass, pearl millet (Andrews and Kumar, 1992) and oats (Singh *et al.,* 2000) can accumulate nitrate at potentially toxic levels. Nitrate poisoning is better described as nitrite poisoning. When livestock consume forages, nitrate is normally converted in the rumen from nitrate to nitrite to ammonia to amino acid to protein. When forages have an unusually high concentration of nitrate, the animal cannot complete the conversion and nitrite accumulates. Nitrite is absorbed into the bloodstream directly through the rumen wall and converts haemoglobin (the oxygen carrying molecule) in the blood to methaemoglobin, which cannot carry oxygen. The blood turns to a chocolate brown color rather than the usual bright red. An animal dying from nitrate (nitrite) poisoning actually dies from asphyxiation, or lack of oxygen (Benjamin, 2006). Factors affecting the severity of nitrate poisoning are the rate and quantity of consumption, type of forage, energy level or adequacy of the diet. Benjamin (2006) reported that sheep and cattle fed poor diets seem to be more susceptible to nitrate poisoning.

2.6. *Protease Inhibitors*

Protease inhibitors are widely distributed within the plant kingdom, including the seeds of most cultivated legumes and cereals. Protease inhibitors are the most commonly encountered class of antinutritional factors of plant origin. Protease inhibitors have the ability to inhibit the activity of proteolytic enzymes within the gastrointestinal tract of animals. Due to their particular protein nature, protease inhibitors may be easily denatured by heat processing although some residual activity may still remain in the commercially produced products. The antinutrient activity of protease inhibitors is associated with growth inhibition and pancreatic hypertrophy (Chunmei et al., 2010).

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2.7. *Alkaloids*

Alkaloids are one of the largest groups of chemical compounds synthesised by plants and generally found as salts of plant acids such as oxalic, malic, tartaric or citric acid. Alkaloids are small organic molecules, common to about 15 to 20 per cent of all vascular plants, usually comprising several carbon rings with side chains, one or more of the carbon atoms being replaced by a nitrogen. They are synthesized by plants from amino acids. Decarboxylation of amino acids produces amines which react with amine oxides to form aldehydes. The characteristic heterocyclic ring in alkaloids is formed from Mannich-type condensation from aldehyde and amine groups .

The chemical type of their nitrogen ring offers the means by which alkaloids are subclassified: for example, glycoalkaloids (the aglycone portion) glycosylated with acarbohydrate moiety. They are formed as metabolic by products. Insects and hervibores are usual1y repulsed by the potential toxicity and bitter taste of alkaloids . Alkaloids are considered to be anti-nutrients because of their action on the nervous system, disrupting or inappropriately augmenting electrochemical transmission. For instance, consumption of high tropane alkaloids will cause rapid heartbeat, paralysis and in fatal case, lead to death. Uptake of high dose of tryptamine alkaloids will lead to staggering gate and death. Indeed, the physiological effects of alkaloids have on humans are very evident (Habtamu and nigusse,2014).

2.8. Phytate

Phytate, which is also known as inositol hexakisphosphate, is a phosphorus containing compound that binds with minerals and inhibits mineral absorption. The cause of mineral deficiency is commonly due to its low bioavailability in the diet. The presence of phytate in feeds has been associated with reduced mineral absorption due to the structure of phyate which has high density of negatively charged phosphate groups which form very stable complexes with mineral ions causing non-availability for intestinal absorption (Walter *et al*., 2002). Phytates are generally found in feed high in fibre especially in wheat bran, whole grains and legumes (Thava & James, 2001).

2.9. *Mycotoxins*

Mycotoxins are those secondary metabolites of fungi that have the capacity to impair animal health and productivity (D'Mello and Macdonald, 1998). The diverse effects precipitated by these compounds are conventionally considered under the generic term "mycotoxicosis", and include distinct syndromes as well as nonspecific conditions. Mycotoxin contamination of forages and cereals frequently occurs in the field following infection of plants with particular pathogenic fungi or with symbiotic endophytes. Contamination may also occur during processing and storage of harvested products and feed whenever environmental conditions are appropriate for spoilage fungi. Moisture content and ambient temperature are key determinants of fungal colonization and mycotoxin production. It is conventional to subdivide toxigenic fungi into "field" (or plantpathogenic) and "storage" (or saprophytic/spoilage) organisms. *Claviceps, Neotyphodium, Fusarium* and *Alternaria* are classical representatives of field fungi while *Aspergillus* and *Penicillium* exemplify storage organisms. Mycotoxigenic species may be further distinguished on the basis of geographical prevalence, reflecting specific environmental requirements for growth and secondary metabolism. Thus, *Aspergillus flavus, A. parasiticus* and *A. ochraceus* readily proliferate under warm, humid conditions, while *Penicillium expansum* and *P. verrucosum* are essentially temperate fungi. Consequently, the *Aspergillus* mycotoxins predominate in plant products emanating from the tropics and other warm regions, while the *Penicillium* mycotoxins occur widely in temperate foods, particularly cereal grains. *Fusarium* fungi are more ubiquitous, but even this genus contains toxigenic species that are almost exclusively associated with cereals from warm countries.

2.10. *Aflatoxins and Gossypol*

This group includes aflatoxin B1, B2, G1 and G2 (AFB1, AFB2, AFG1 and AFG2, respectively). In addition, aflatoxin M1 (AFM1) has been identified in the milk of dairy cows consuming AFB1-contaminated feeds. The aflatoxigenic *Aspergilli* are generally regarded as storage fungi, proliferating under conditions of relatively high moisture/humidity and temperature. Aflatoxin contamination is, therefore, almost exclusively confined to tropical feeds such as oilseed by-products derived from groundnuts, cottonseed and palm kernel. Aflatoxin contamination of maize is also an important problem in warm humid regions where *A. flavus* may infect the crop prior to harvest and remain viable during storage. Surveillance of animal feeds for aflatoxins is an ongoing issue, owing to their diverse forms of toxicity and also because of legislation in developed countries (D'Mello and Macdonald, 1998). Gossypol pigment in cottonseed occurs free and bound forms. In whole seeds, gossypol exists essentially in the free form, but variable amounts may bind with protein during processing to yield inactive forms. Free gossypol is the toxic entity and causes organ damage, cardiac failure and death. Cottonseed meal fed tobulls can induce increased sperm abnormalities and decreased sperm production.

3. MECHANISM OF TOXICITY

Tannins may form a less digestible complex with dietary proteins and may bind and inhibit the endogenous protein such as digestive enzymes. The tannin-protein complexes are astringent and adversely affect feed intake and all plants contains phenolic compounds but their type and

concentration may cause negative animal responses (*Smitha et al., 2013)*. The concentration of condensed tannins above 4 per cent has been reported to be toxic for ruminants as they are more resistant to microbial attack and are harmful to a variety of microorganisms (Waghorn , 2008). It has been reported that saponins can affect animal performance and metabolism in a number of ways as follows: erythrocyte haemolysis, reduction of blood and liver cholesterol, depression of growth rate, bloat (ruminants), inhibition of smooth muscle activity, enzyme inhibition and reduction in nutrient absorption (Akande *et al.,* 2010).

Phytic acid acts as a strong chelator, forming protein and mineral-phytic acid complexes; the net result being reduced protein and mineral bioavailability (Khare, 2000). Phytic acid is reported to chelate metal ions such as calcium, magnesium, zinc, copper, iron and molybdenum to form insoluble complexes that are not readily absorbed from gastrointestinal tract. Phytic acid also inhibits the action of gastrointestinal tyrosinase, trypsin, pepsin, lipase and amylase (Khare, 2000). Similarly Oxalic acid binds calcium and forms calcium oxalate which is insoluble. Calcium oxalate adversely affects the absorption and utilization of calcium in the animal body (Akande et al., 2010). Trypsin inhibitors have been implicated in reducing protein digestibility and in pancreatic hypertrophy.

4. METHODS TO REDUCE THE LEVEL OF ANTI-NUTRITIONAL SUBSTANCES IN THE FEED

The abundance of anti-nutritional factors and toxic influences in plants used as human foods and animal feeds certainly calls for concern. Therefore, ways and means of eliminating or reducing their levels to the barest minimum should be discovered (Soetan and Oyewole, 2009**)**. Removal of undesirable components is essential to improve the nutritional quality of legumes and effectively utilize their full potential as poultry feed ingredient. It is widely accepted that simple and inexpensive processing techniques are effective methods of achieving desirable changes in the composition of seeds (Akande and Fabiyi, 2010).

Various methods have been attempted to de-activate tannins in a wide range of browse species, grain seeds and agro-industrial by-products (Makkar, 2000). These methods have included mechanical or physical techniques (e.g. wilting, processing, ensiling, etc.), inoculation with tannin resistant bacteria and chemical techniques (treatment with alkalis, organic solvents, precipitants, etc.). The use of polyethylene glycol for which tannins have higher affinity than for proteins, is by far the most used reagent to neutralize these secondary compounds (Muller I., 2001). Most tannins are located in seed coats (skin) and hulls while fruit (meat nut) are practically tannin free (Shahidi and Nazck, 2004). Reductions in tannins contents of cow pea ranged from 6.7% to 68.5% in boiled, microwave cooked and autoclaved peanut seeds((Embaby,2011). Soaking at ambient temperature had the least reduction (15%) while soaking at 60°C for 7h had the highest reduction (61%) of tanini contents in Tigernut **(***Adekanmi et al., 2009).*

The phytate molecule is negatively charged at the physiological pH and is reported to bind essential, nutritionally important divalent cations, such as iron, zinc, magnesium and calcium.

This forms insoluble complexes, thereby making minerals unavailable for absorption (Frontela *et al.*, 2008). Longer time of boiling, microwave and autoclaving resulted in lower levels of phytic acid. Thus, autoclaving for 20 min was the most effective for phytic acid reduction (24.7% loss). Roasting of sesame is more effective (the reduction ranged from 15.6% to 22%) than boiling and microwave (the reduction ranged from 3.8% to 11.8%) for phytic acid. Roasting can cause a significant reduction (the reductions up to 23.1 - 28.6 %,) in phytic acid contents of other seeds (Embaby,2011). Similarly longer time of both boiling (for 40 min) and autoclaving (for 20 min) caused a complete inactivation of trypsin inhibitor activities, but the longer time of microwave (12 min) reduced trypsin inhibitor activities by 61.5%

Boiling , simmering and blanching caused significant reduction in the level of cyanide content of *Moringa oleifera* leaves by 88.10%, 80.95% and 61.90% respectively(Sallau et al., 2012). Boiling also reduces oxalate content *Arachis hypogaea* L (Groundnut)from 3.04 mg/g 2.62 mg/g , trypsin inhibitor from 0.12 TUI/g to 0.09 TUI/g (Mada et al., 2012). Soaking Asparagus Bean (*Vigna Sesquipedis) results* in reduction of alkaloids from 0.34 to 0.28% tannin 0.23 to o.09% saponin 0.42 to 0.24%; HCN 8.63 to 5.68%; phytate 0.18 to 0.09 and trypsin inhibitor 13.82 to 9.41 TlU/100g(NWOSU, 2010). Gharaghani et al. (2008) reported the effect of gamma irradiation on anti nutritional factors and nutritional value of canola meal for broiler chickens. Glucosinolate content was reduced to 40, 70 and 89% at rradiation dose levels of 10, 20 and 30 kGy, respectively. *Using electron beam (EB) radiation method was found that a radiation of 9.33 KGy was found to reduce hydrocyanic acid, phytic acid and tannic acid to the extent of 34, 63, and 22%, respectively (*Hasnat et al., 2014).

On the other hand germination followed by dehulling reduces phytic acid and tannin by 47–52% and 43–52%, respectively(Ghavidel and Prakash, 2006). In general, amongst the various processing methods (*boiling, toasting and soaking)* employed, the soaking method was found to reduce the levels of various anti-nutritional substances (Balogun, 2013). Fermentation can also reduce the level of some antinutritional factors in feed. Sarangthem and Singh (2013) reported that phytate content of 35.95mg/100g and30.67mg/100g in fresh bamboo shoots of *Dendrocalamus hamiltonii* and *Bambusa balcooa* reduce to 22.46mg/100g and 24.12 mg/100g in the traditional fermented and laboratory fermented samples respectively. However, in the same report tannin content of 31.49mg/100g and 45.49mg/100g in fresh bamboo shoots of *Dendrocalamus hamiltonii* and *Bambus abalcooa* respectively increases to 68.21mg/100g and 52.00mg/100g fresh wt. in the traditional and laboratory fermented samples.

5. BENEFICIAL EFFECTS OF ANTINUTRIENTS

Excessive degradability of proteins could be reduced by the use of heat and various chemicals. The use of heat is very expensive, thus most often the chemicals, such as formaldehyde, are used. However, the formaldehyde is carcinogenic and, in addition, its incorrect use can lower the absorption of amino acids from intestine. Another way to protect proteins against excessive degradation in the rumen is the use of tannins, which form reversible complexes with proteins. These complexes are not degraded at pH values present in rumen (Butter et al., 2000), but they disintegrate at pH values of the abomasum and small intestine (Jones and Mangan, 2003).

The positive of tannin in animal feeing includes; increased efficiency of protein utilization, reduction of parasite burden, reduction of proteolysis during ensilage, bloat prevention, increase quality of animal products, reduction of n emission into the environment and defaunate rumen (adesogan, 2004). Condensed tannins (CT) have improved live weight gain, wool production and reproductive efficiency in sheep fed temperate forages and reduced the impact of gastro-intestinal parasitism. However, their value is also linked to environmental issues, such as reducing nitrogen pollution from animals grazing lush pastures with a high nitrogen content and lessening methane emissions from rumen fermentation (Waghorn, 2008).

Saponins have shown a variety activities such antitumor, cholesterol lowering, immune potentiating, anticancer, antioxidants (Blumert and Liu, 2003) and to presser lower risk of implicated in coronary heart diseases (Ferri, 2009), and saponins potential as ointment hydrocarbon to shape of first collagen, there is protein have a role in recovery process of wound healing.

Potential beneficial effects of protease inhibitors remain unclear, although lower incidences of pancreatic cancer have been observed in populations where the intake of soybean and its products is high. While protease inhibitors have been linked with pancreatic cancer in animal studies, they may also act as anticarcinogenic agents (Chunmei et al., 2010).

6. FEEDING MECHANISMS OF FEEDS WITH ANTI-NUTRITIONAL FACTORS

Polyethylene glycol was supplied to animals on tannin-rich diets in different ways (in concentrate or feed blocks, dissolved in water, or sprayed on feed). Feed block, a solidified blend of agro-industrial by-products, was found to be an efficient supplement for increasing intake, rumen fermentation, digestibility and daily weight gain in sheep or goats fed on shrub foliage high in tannins. The advantage of these supplements lies in the synchronized, fractionated and balanced supply of main nutrients to rumen microflora and the host animal on tannin-rich diets, results attributable to the slow release of polyethylene glycol on licking of the block by the animal. This slow-release characteristic provides an economic use of this relatively costly tannin-inactivating compound, and maximizes its positive effect on the fodder potential of tanniniferous browse or tree species (*Smitha et al., 2013).*

7. SUMMARY

The presence of antinutrients in plant protein sources for livestock feeding is a major constraint that reduces their full utilization. To be able to justify the overall nutritional potential or value of any plant protein source, proper assessment of the type, nature and concentration of the antinutrients present in the protein source and also the bioavailability of nutrients to the ingesting animal is necessary. Employing appropriate and effective processing techniques or combination of techniques could help reduce or eliminate the adverse effects of these antinutritive constituents in plant protein sources and thereby improve their nutritive value. Supplementation of some minerals, animo acids and vitamins could help reduce or neutralize the negative effect of antinutritional factors in plant protein sources for livestock nutrition. The concentration or level of the antinutritive constituents in these protein sources vary with the species of plant, cultivar and post-harvest treatments (processing methods). Since antinutrients vary among plant cultivars, therefore the use of genetically improved low-antinutritive cultivars or varieties could be a possible option for livestock feeding.

Germination combined with dehulling process improved quality of legumes by enhancing the bioavailability and digestibility of nutrients and reducing the antinutrients. Result from this study suggested that electron beam irradiation can be opted as a simple and user friendly method to reduce the ANFs in fish feed. 9.33 KGy EB radiation can be considered as the optimum level to reduce tannin, phytic acid and hydrocyanic acid from unconventional aqua-feed ingredients. As a physical process, EB irradiation definitely has an upper hand against conventional methods in the reduction of anti-nutrients.

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