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Toxic Substances Arise from Forage Plants and Solution Proposals

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Abstract
There are some substances which can create negative effects in different forms and which have generally organic structures in the grass-pasture, forage plants and forage rations. Plants have naturally these substances. Moreover, they lead to some negatives effects during preparations, storing and maintenance processes and they can create problems for animals. In order to enable us to benefit from the forage resources of animals more efficiently, they will improve the livestock sector. Toxic substances occurring naturally in the grass-pasture, forage plants and forage rations can decrease and impede this availability level. The aim of this study is to evaluate some toxic substances arise from forage plants and to present the solution proposals.
Key Words: Forage plants, toxic substances, animal performance, alkaloid, coumarin

Yem Bitkileri Kaynaklı Zehirli Maddeler Ve Çözüm Önerileri

Özet
Çayır- mera, yem bitkileri ve yem rasyonlarında genellikle organik yapıya sahip, çeşitli şekillerde olumsuz etkiler yaratabilen bazı maddeler mevcuttur. Bu maddeler bitkilerin bünyelerinde doğal olarak bulunabilmektedir. Bununla birlikte hazırlanmaları, depolanmalar, bakım işlemleri sırasında da meydana gelen problemlerde çeşitli olumsuzluklara sebep olup, hayvanlar üzerinde ciddi sıkıntılara yol açabilmektedir. Hayvanların yem kaynaklarından daha etkin şekide yararlanabilmelerini sağlamak hayvancılık sektörünü geliştirecektir. Çayır, mera ve yem rasyonlarında doğal olarak meydana gelen zehirli maddeler bu yararlanılabilirlik düzeyini azaltmakta ve engellemektedir. Bu çalışma ile yem bitkileri kaynaklı zehirli maddelerin bir kısmına ve çözüm önerilerine ilişkin açıklamalara değinilmeye çalışılacaktır.
Anahtar Kelimeler: Yem Bitkileri, zehirli maddeler, hayvan performansı, alkaloid, kumarin

INTRODUCTION

The main aim for the animal production is to increase the productivity for per unit in return for per expense. The most important factors for this increase are to use highly productive animal varieties, to ensure efficient maintenance and to feed animals properly. Nevertheless, the most important part of problems for the animal production results from feeding and fodder utilization. The most important sources for feeding and fodder utilization are grass and pasture. The forage plants are very important because they give highly productive animal products, they are rich with minerals and vitamins and they have the foodstuffs necessary for animals [1]. Both forage plants have numerous advantages which are very important for the livestock farming and they have naturally toxic substances. These negative factors lead to not benefit from forages properly and to decrease the live weight gains or the productivity [2; 3; 4; 5; 6].

Within the scope of article, some toxic substances arise from forage plants and the solution proposals for these are addressed.

Toxic Substances Arise From Forage Plants

Livestock have a number of physiological reactions to toxic and poisonous plants that may help condition them to avoid such poisoning. In other cases, animals die because toxicity is acute (requires extremely small amounts of plant matter) or the animal ingests the plant as a large percentage of its diet in a brief period. Plant toxicity can vary depending on the animal species, animal condition, growth form of the plant, plant subspecies, plant age, whether the toxin accumulates as a residue, inherent toxin potency, what percentage of the animal's diet was made up of the plant, and whether other toxins were also consumed.

Mycotoxins

These toxins produced by funguses living in the plant tissues, having the chemical structure and having the negative effects for animals are defined as mycotoxin. Animals consuming the forages contaminating with these toxins are affected by mycotoxins. As a result of this, a disorder called as *mycotoxicosis* is observed in animals [7]. The contamination level of mycotoxins can differ from season to season, from year to year by basing on the climatic conditions, the product type and the geographical position [8]. The physical, chemical and biological factors affecting mycotoxins are presented in the following in table 1.

Table 1. Factors affecting mycotoxin production [9].

Physical factors	Chemical factors	Biological factors
Humidity	CO_2	Fungal infection, inoculum amount
Substract humidity	O_2	Plant type, plant durability
Drying rate	Substract structure	Plant stress, plant diseases
Relative air humidity	Chemical implementations for substract	Genetic differences between funguses
Temperature	Chemical process (fertilizing, disinfestation)	Relationship between microorganism
Mechanic damaging		Activity of pests
Time		Fungal isolate differences
Combination of cereals		

Mycotoxins; they are fungal metabolites which are produced by some fungus, especially Aspergillus, Penicillium, Fusarium, Alternaria, in a specific temperature and humidity conditions [10; 11]. Aflatoxine, ochratoxin, trichothecene, zearalenon, patulin and fumonicine can be evaluated as the most encountered mycotoxins [12].

Conserve coarse fodder such as silage, fodder and dried vegetation are the most important resources for mycotoxin and they can create problems in the dairy farming [13]; [14]. Some disorders can be observed in the animals grassed in the pastures which have densely *Festuca arundinacea* and humid soil. It is founded that the reason of these disorders is a fungus named *Acremonium coenophialum*. Animals feeding from these plants contaminated with the fungus can experience three different eating disorders as fescue foot, bovine fat necrosis and fescue toxicosis as a result of mycotoxins [15]. Especially in the USA, the cost of fescue toxicosis is estimated as 600 million dollars [15]. It is also determined that *Lolium perenne* L. and *Lolium mutiflorum* var. *italicum* in *Acremonium lolii* fungus can create '*Ryegrass stragger*', in other words grass pea. Some neural disorders such as dystonic movements, athetosis and spasm are observed in animals feeding from these grass plant contaminated with this fungus and the weight increase decreases in animals. Changing the feed will spontaneously remove the problem for the disorders such as grass pea.

The disorders which animals living in the areas contaminated with mycotoxins have and the productivity loss arise from this are very important issues. In order to decrease this loss and to protect animals from mycotoxins, animals' feed should be regarded, they shouldn't be fed with moldy feeds and moldy feeds shouldn't be given to animals. The humidity rate of products or feeds after harvest should be decreased and storing should be conducted in low temperatures. In order to decrease this problem, seed not contaminated with fungus or durable types should be used.

Alkoloids

Nitrogenous compounds which are naturally produced by plants and have harsh-tasting and complicated structure are defined as ' alkaloid'. Alkaloids are difficult to define because of their diversity. There are many alkaloids isolated from forage plants. There are inverse relationship between the increase of alkaloid concentration and tastiness. On the other hand; anti-quality components such as alkaloids; are found in some legume species and if present in high concentrations can reduce animal performance and breeding. A review of anti-quality compounds in clovers is presented by Essig [16]. Animals which get damaged because of alkaloids can encounter many serious disorders. The destruction of nervous system, the impairment of brain and spinal cord and sudden deaths can explain the serious damages and results of alkaloids against animals. These results have a close relationship with the type and amount of alkaloid.

Phalaris arundinacea paralysis is a disorder arise from *Phalaris aquatica* called as *' Phalaris stragger'*. It is a very common disorder which is observed in sheep and beefs which are grassing in the pastures of *Phalaris arundinacea* in Australia and are feeding with its fodder. Animals with this disorder resulting from triptamin alkaloids can have the destruction of nervous system, the impairment of brain and spinal cord and sudden deaths [17]. Ruelke and McCall [18] observed that a similar chronic condition with sheep grazing '*ronphagrass'* (*Phalaris acquatica* x *Phalaris arundinacea* hybrid). They suggested that the condition could be prevented by cobalt supplementation of the diet as reported for "*Ronpha staggers*" in North Africa [18; 19].

Blakeslee et al. [20] obtained lower average daily gain of lambs and ewes grazing reed canarygrass than those grazing bromegrass. Nine alkaloids have been isolated from reed canarygrass [19; 21]. The main ones of problems encountering in the areas in which animals are feeding with *Phalaris arundinacea* are rough hair coat and profuse watering of the eyes as well as the reduction in milk production and live weight losses. .

Claviceps purpurea is a disorder which is known to originate from 'Claviceps' alkaloids and which is observed in animal feeding with ear and corymb of *graminae*. Because of this, poisoning can be observed in animals. The genus Claviceps (family *Clavicipitaceae*) contains the species *Claviceps pupurea* which is well known for its role in ergot poisoning. The role of fungi in producing toxicity in livestock has been given recent consideration regarding "*bermudagrass tremors*".

Lupinus L. and *Lathyrus* L. types among *leguminosae* are very toxic types because of alkaloids. A disorder called as *Lupinosis* is observed in sheep as well as beefs and horses who are feeding with the types of *Lupinus* L. This disorder can lead to expansion and adiposity in lungs, nephrosis and even deaths. The effect of *lupinosis* increase after raining. Therefore, while improvement can be observed for animals extracting from grassed areas in the starting of event, deaths can be observed if grassing is kept going.

Glycosides

Plants have very toxic glycosides. The most common ones among them are glucosinolates, cyanogenic glycosides, coumarins and saponin. These substances become active when plant tissues get damaged.

The factors affecting the glycoside concentration;

- Physiological factors, such as water deficit and nutrient deficiencies,
- Stage of growth,
- Accumulation in specific plant tissues,

- Geographic or topographic location and seasonal effects of soil and climate.

Hydrocyanic acids

Cyanogenic glycosides are plant-specific and at least 55 cyanogenic glycosides have been identified so far [22]. Prussic acid is not normally present in plants but under certain conditions, several common plants can accumulate large quantities of cyanogenic glycosides which can convert to prussic acid. Grazing and barnyard livestock is in very dangerous situation, because of prussic acid or hydrocyanic acid risk. Under stress conditions; such as wilting, frosting, stunting, drought, the glycoside degrades to form free HCN which is extremely toxic to livestock.

Even if the potentiality of storing prussic acid (HCN) is specified for plants in the table 3 below, hydrocyanic acid poisoning is a very significant problem for *Sorghum* varieties. Leaves and stems of all sorghum species can contain prussic acid glycosides. These plants have *Dhurrin* substance as glycoside. If leaves are damaged, the *dhurrin*, releasing cyanide. *Dhurrin* concentration for plants depend on kind, growth term, cultivation conditions, climate condition and especially implemented N fertilizer [23]. The concentration of hydrocyanic acid increase together with excessive nitrogenous fertilizer practice in very arid and cold periods. While this rate is high for young term of plant, it begins to decrease with maturation [24]. In order to minimize this problem, sorghum types are advised not to grass in a very young term and after frosting. Moreover, it is very rare to encounter the prussic acid (HCN) poisoning together with ensilaging sorghum plants. Excessive nitrogen fertilization can increase the damage. N fertilizing should not applied more than 27-36 kg per acre at one time. Immediate treatment by a veterinarian is necessary to save the animals. Two common treatments are intravenous injection (125 to 250 ml) of 1.2% sodium nitrate or 7.4% sodium thiosulfate.

Table 2. Forage plants that accumulate prussic acid include

Forage or plant	Prussic acid potential
Pearl and foxtail millet	very low
Sudangrass and sudangrass hybrids	low or moderate
Sorghum-sudangrass hybrids	moderate to high
Forage sorghum	moderate to high
Shattercane	high
Johnsongrass	high to very high
Grain sorghum	high to very high
Sorghum almum	high to very high
Arrowgrass	low
Velvetgrass	low
White clover	low
Birdsfoot trefoil	low

The effects are seen rapidly on the animals who eats the forage including prussic acid. The symptoms which are result from prussic acid (HCN), excitement, increased respiration rate, labored breathing, salivation, staggering, and collapse. Death results from asphyxiation, which usually occurs within 30 to 45 minutes following onset of symptoms. Cattle and sheep are more susceptible prussic acid toxicity because of their chewing mechanisms and rumen digestion. Sheep generally are more tolerant than cattle. Uptake of *Sorghum vulgare* may be a problem for horses. After the 11 horses nourished with *Sorghum bicolor* for over 2 months, three of 11 horses showed incordination of the hind legs, 7±10 days developed frequent urination, urinary incontinence and haematuria, followed by a serious nasal discharge, increased body temperature, depression and reduced appetite [25].

Table 3. Level of prussic acid in forage (dry matter basis) and potential effect on animals.

Prussic Acid (HCN) ppm	Effect on animals
0-500	Generally safe; should not cause toxicity.
600-1,000	Potentially toxic; should not be the only source of feed.
1,000 and above	Dangerous to cattle and usually will cause death.

Coumarin

Coumarin is a poisonous chemical compounds (benzopyrone) found in many plants, especially as a forage plants, *Melitotus* ssp. has high concentration. It leaves a harsh-tasting in the animals' mouth who is fed with the plants including much coumarin concentration. Therefore, coumarin is known as a material that reduces the flavour of plants and also reduces the quality of forage. After the harvest, as a result of fungal activity, coumarine transform into dicoumarol in the fodder of some plants which are not well dried. *Penicillium nigricans* and *Penicillium Jensinare* the reason of the fungal activity, the nature abound in these mildews [26]. Dicoumarol depresses blood prothrombin concentration and by implication reduces clotting time. More detailed review of the implications of dietary coumarin and dicoumarol in livestock production has been published by Gustine [27].

Coumarins, which are constituents of forage, have been associated with the so-called bleeding disease in cattle consuming spoiled or putrid sweet clover [28]. If mentioning about forage legumes, sweet clover (*Melitotus officinalis* L. Ders) leaves, sour clover (*Melitotus indica* L.) seeds and white sweet clover (*Melitotus alba* L.) leaves and seed contains coumarin [29; 30; 31]. On the other hand, for grasses, sweet vernalgrass (*Anthoxanthum odoratum* L.) and sweet grass (*Hierochloe odorata* L. Beauv.) contains coumarin too. They are found spontaneous plants in pasture and meadows [32]. Coumarin at 10^{-4} M significantly reduced root lengths of alfalfa and barnyard grass [33]. In U.S.A and Canada, some different kind of forages has been produced to protect the animals from the coumarin's effects. The plants that are not well dried shouldn't be given to the animals. The animals who get coumarine poisoning, have to be injected with vitamin K. This would be effective to minimize the damage. Besides, haycocks should be treated with ammonia to reduce the level of dicoumarol.

Tannins in Phenolic Compounds

Tannins are divided into two groups and they are hydrolyze and condanse tannins. Tannins are described as water soluble polymeric phenolic that precipitate proteins [34]. While tannins limit the digestible rates of plans by decreasing the activity of cellulous enzyme, they also limits the protein digestion.

When the forage plants which have high tannin rate are consumed, the tastiness of these plants and the rate of consumable and digestible rate of these plants by animals will begin to decrease. Therefore, the growth rate of animals will begin to decrease. The most important reason of this decrease is that the tannin rate decrease the benefit of these plants for animals. In the studies which were conducted on the negative effects of tannins, the negative effect on growth increases especially for animals which are mono-stomach, the efficiency of feed decreases and the feed amount consumed for 1 kg live weight increase fosters [35; 36].

When tannin is regarded as a problem, it is very problematic for cereals rather than leguminosae. According to Goplen and Marshall et. al [26; 37], there are no tannins in vegetative organs of clover and white clover varieties, there are tannins in their feeds. While birdsfoot trefoil (*Lotus corniculatus*) have a few tannins, japan clover (*Lespezeda stipulacea*) and sainfoin (*Onobrychis ssp.)* types are among cereals forage plants which are rich of tannins. Problems related to tannin in cereals forage plants are observed at most in *Sorghum* varieties. It is determined in the conducted studies that the digestible rate is between 50-96% as to the tannin concentration and a negative correlation is observed [38; 39].

In order to minimize the tannin problem, the varieties which have no tannin or have a few tannin should be produced. In the past years, many studies were conducted in relation with this but the types which have tannin in the non-problematic amounts should be developed in the recent days.

CONCLUSION

The animal products are nutrient materials which are rich of proteins, minerals and vitamins and they are very important in human nourishment. Also, the increase of animal production and consumption is parallel with the development level of that country, this increase is directly related with the animal health and performance. As specified in the article, these toxic materials which are naturally in the forage plants are factors which have directly negative effects for animal health and performance. Grasses and pastures are effectively used in our country and it is an indispensable problem that these varieties of problems should be minimized in the forage rations and in pastures and grasses. The most important input is feed for the animal culture and it comprises 70 % of total expenses. This rate is significantly high and the proposals to be taken should be given much importance. Feeds for animals should be regarded, animals shouldn't be fed with forages contaminated with moldy substances and storing after harvest should be regarded. Excessive-fertilizing in grasses and pastures and the periods of entering in grass and pastures for animals should be conducted with a well-designed plan. Animals shouldn't be grassed while they are hungry as soon as possible. The varieties which have a few toxic substances or have no toxic substances should be developed and they should be presented for the usage of farmers and animal producers. The negative effects of substances and the disruption for animals should be understood by many farmers and animal producers if possible and the workshops and publishing studies should be conducted. Therefore, the grass-pasture management should be implemented more consciously and the forage plants producers and animal producers will have better consumption and production potentiality.

REFERENCES

[1] Serin Y. ve Tan M. 2001. Yem Bitkileri Kültürüne Giriş. Atatürk Üniversitesi Ziraat Fakültesi Yayınları, No: 206, 217s., Erzurum.

[2] Bondi A and Alumot R. 1987. Anti-nutritive factors in animal feed stuffs and their effects on livestock. Progress in Food and Nutrition Seienee, LL: II 5-15 1.

[3] Clarke JML, Harvey DG and Humphreys DJ. 1981. Veterinary toxieology. Second edition. Bai1liere Tindalı. London.

[4] Hatclı HC. 1988. Poisons eausing respiratory insufficiency. p. 1001-1131. In: "Veterinary Pharmacology and Thcrapeuties". Eds. N.H. Bootlı and L.E. MeDonaId. Sixth ed., Iowa State University Press. Ames.

[5] Humpreys DJ. 1979. Poisoning in poultry worlds. Poultry Sei., 35:161-176.

[6] Jordan FT, Howell JM, Howarth J and Rayton JK. 1971. Clinical and pathologieal observations on field and experimental zoalene poisoning in broiler chieks and laying hens. Avian Path., 5: 175-178.

[7] Whitlow, L.W. ve Hagler W.M. 2005. Mycotoxins: a review of dairy concerns. Mid-South Ruminant Nutrition Conference, 47-58.

[8] Girgin G. 2001. Dünyada ve Türkiye'de İnsan Sağlığını Tehdit Eden Mikotoksinler, Mycotoxins in Turkey and the World, Türk Hijyen ve Deneysel Biyoloji Dergisi, 58 (3): 97–118

[9] Kielstein P. 1993. Pilze als Krankheitserreger bei Mensch und Tier. In: Allgemeine Mikologie (ed. Weber, H.).Gustav Fischer Verlag Jena-Stuttgart. 467-505.

[10] Soyoz M, Ozcelik N. 2002. Okratoksin A'nın Toksik Etkileri ve Eliminasyonu, T. Klin. J.Med. Sci., 22, 421.

[11] Tanker M, Soner O, Sahin AA, Kaya S, Dulger G, Ersoy O, Omurtag G, Yurdun T. 1995. Aflatoksinler ve Besinlerle Sağlığımız Üzerinde Oluşturabileceği Tehlikeler, Eczacı Dergisi, Nisan, 16.

[12] Huwig, A., Freimund, S., Kappeli, O. 2001. Dutler H. Mycotoxin Detoxification of Animal Feed by Different Adsorbants, Toxicol. Lett., 122, 179.

[13] O'Brien M, O'Kiely P, Forristal PD, Fuller HT. 2005. Fungi isolated from contaminated baled grass silage on farms in the Irish Midlands. FEMS Microbiol Lett. 247:131–135.

[14] Mansfield MA ve Kuldau GA. 2007. Microbiological and molecular determination of mycobiota in fresh and ensiled maize silage. Mycologia. 99:269–278

[15] Sleper DA And Buckner RC. 1995. The Fescues. In: R.F. Barnes, D.A. Miller and Nelson C.J. (Eds) Forages, Iowa State University Press, Ames, Iowa, p. 345-356

[16] Essig HW. 1985. Quality and antiquality components. p. 309–324. In N.L. Taylor (ed.) Clover science and technology. Agron. Monogr. 25. ASA, CSSA, SSSA, Madison, WI.

[17] Mayland HF and Cheeke PR. 1995. Forage-inducedanimal disorders. In: R.F. Barne, D.A. Miller and Nelson C.J (Eds) Forages, Iowa State University Press, Ames, Iowa, p. 147-162

[18] Ruelke OC and McCall JT. 1961. Evaluation of ronphagrass for pasture. Agron. J. 53:406.

[19] Marten GC. 1973. Alkaloids in reed canarygrass. Page 15 in Antiquality components of forages. Crop Sci.

Soc. Amer. Special Pub1. No. 4. Arthur G. Matches, ed. Crop Sci. Soc. Amcr., Madison, WL

[20] Blakeslee LH, Harrison CM, and Davis JF. 1956. Ewe and lamb gains on brome and reed canarygrass pasture. Mich. Agr. Exp. Sta. Quart. Bull. 39:230.

[21] Gander JE, Marum P, Marten GC and Hovin AW. 1976. The occurrence of 2-methyl-i, 2, 3, 4-tetrahydro-B-carboline and variation in alkaloids in *Phalaris arundinacea*. Phytochemistry 15:737.

[22] Knight AP and Walter RG. 2001. Plants Causing Sudden Death. In A Guide to Plant Poisoning of Animals in North America. Jackson, WY: Teton NewMedia.

[23] Açıkgöz E. 2001. Yem Bitkileri. Bursa. S:371. 3. Baskı. Türkiye

[24] Gullingham JT, Shirer MM, Starnes JJ, Page and McClain EF. 1969. Relative occurance of toxic concentration of cyanide acide nitrate in varieties of sudangrass hybrids. Agron. J. 61:727-730

[25] Varshney JP, Gupta AK, Yadav MP, 1996. Occurrence of ataxia-cystitis syndrome in horses fed on *Sorghum vulgare* in India. Indian Veterinary Journal 73, 985±986.

[26] Goplen BP. 1980. Sweet clover production and agronomy. Can. Vet. J. 21:149-151

[27] Gustine DL. 1972. Allelochemistry and Forage crops. Proc. of Symp. CSSA, Miami Beach, Florida.

[28] Aletor VA. 1993. Allelochemicals in plant foods and feeding Stuffs. Part I. Nutritional, Biochemical and Physiopathological aspects in animal production. Vet. Human Toxicol. 35(1): 57-67.

[29] Haskins FA and Gorz HJ. 1957. Fluorimetric Assay of Free and Bound Coumarin in Sweeetciover. Agron. J., 49, 493-497

[30] Haskins FA and Gorz HJ. 1961. Reappraisal of the Relationship Between Free and Bond Coumarin in Melilotus. Crop Sci., 1, 320-323

[31] Buttery RG, Ling LC and Bean MM. 1978. Coumarin Off-Odourin Wheat Flour. J. Agric. Food Chem., 26, 179-180

[32] F. Crescini, In: Piante Erbacee Coltivate. 1969. pp 565-566, Ramo Editoriale degli Agricoltori, Roma.

[33] Sang-Uk C, Seong-Kyu C, Hong-Gi J, Byoung-Sik P, Sun-Min K. 2002. Effects of alfalfa leaf extracts and phenolic allelochemicals on early seedling growth and root morphology of alfalfa and barnyard grass. Crop production. Volume 21, Issue 10. Pages 1077–1082

[34] Haslam E. 1989. Plant Polyphenols-Vegetable Tannins Revisited. Cambridge University Press, Cambridge, U.K.

[35] Martin- Tanguy J, Guillaume and Kossa A. 1977. Condensed tannins in horse bean seeds. Chemical structure and apparent effect on poultry. J. Sci. Food and Agr. 28: 757-765

[36] Moseley G and Griffiths DW. 1979. Varietal variation in the anti-nutritive effects of field beans (Vicia faba) when fed to rats. J. Sci. Food. Agric. 30: 772-778

[37] Marshall DR, Broue P and Munday J. 1979. Tannins in pasture legumes. Aust. J. Exp. Agr. Anim. Husb, 19:192-197

[38] Arslan A ve Anlarsal AE. 1996. Güneydoğu Anadolu Bölgesi koşullarında farklı tohumluk miktarlarının bazı adi fiğ (*Vicia sativa*. L) çeşitlerinde ot verimi ve bazı özelliklerine etkisi üzerinde bir araştırma. Türkiye 3. Çayır Mer'a ve Yem Bitkileri Kong. 17-19 Haziran 1996. S. 641-647

[39] Harris HB, Cummins DG, Burns RE. 1970. Tannin content and digestibility of Sorghum grain as influenced by bagging. Agron. J. 63: 500-502.