Antinutritional Factors in Forages

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Antinutrients

Definition

Substances which either by themselves or through their metabolic products, interfere with food utilisation and affect the health and production of animals

General characteristics

- Products of secondary metabolism
- Found in virtually all plants to some degree
- Common in tropical forages
- Defensive role:
  - Bitter, colors, poisonous, odor, antinutritive / immunosuppresive

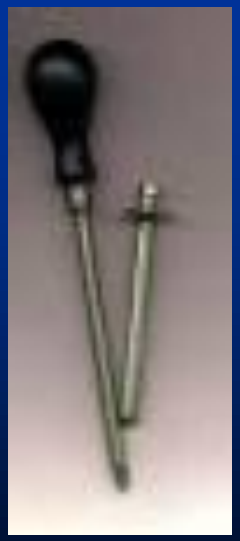
Glycosides

- Generally bitter
- Structure
  - Contain CHO and non-CHO moiety (aglycone)
- Mode of action
  - Toxicity results from aglycone release during enzymic degradation
- Sources
  - Linseed, cassava, sorghum, soya, clover etc
- Sub-Groups
  - Cyanogenic
  - Goitrogenic
  - Coumarin
  - Nitropropanol
  - Carcinogenic
  - Isoflavons (phytoestrogens)
  - Steroidal (Saponins)

Glycosides - effects

- Phytoestrogens
  - E.g. Formononetin in Red & Subterranean clover
    - Female sterility
  - E.g. Genistein in soya
    - Estrogenic activity & male sterility
- Saponins
  - Have distinctive foaming characteristics
  - E.g. in White clover, alfalfa, Brachiaria decumbens & Panicum spp.
  - Cause bloat, hemolysis, GIT erosion, inhibit enzyme action

Saponins

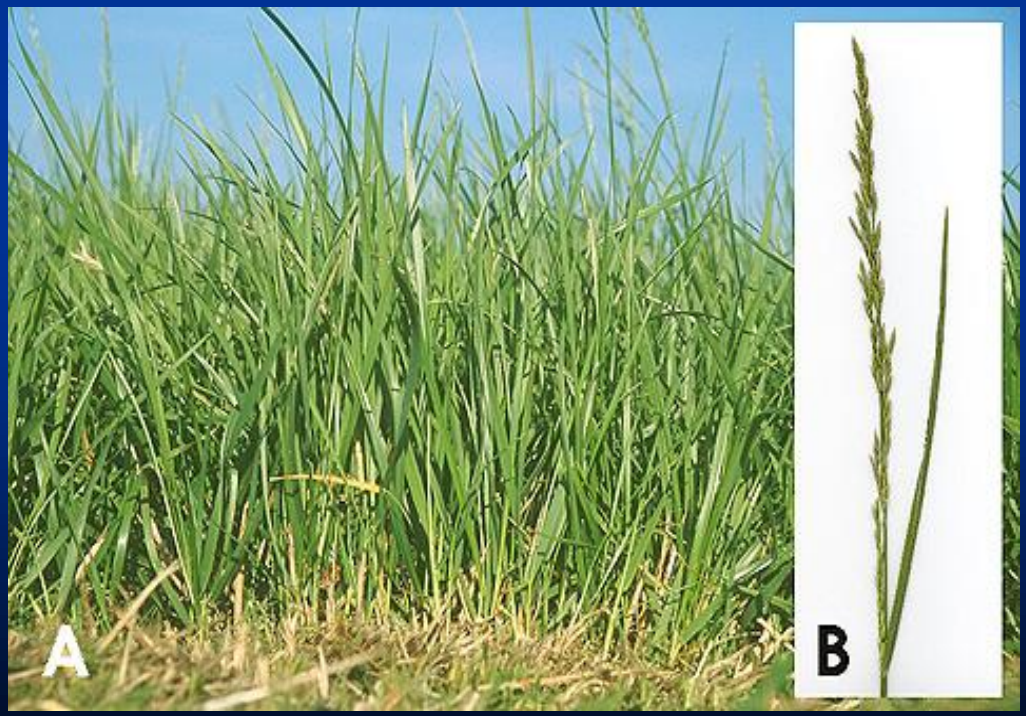


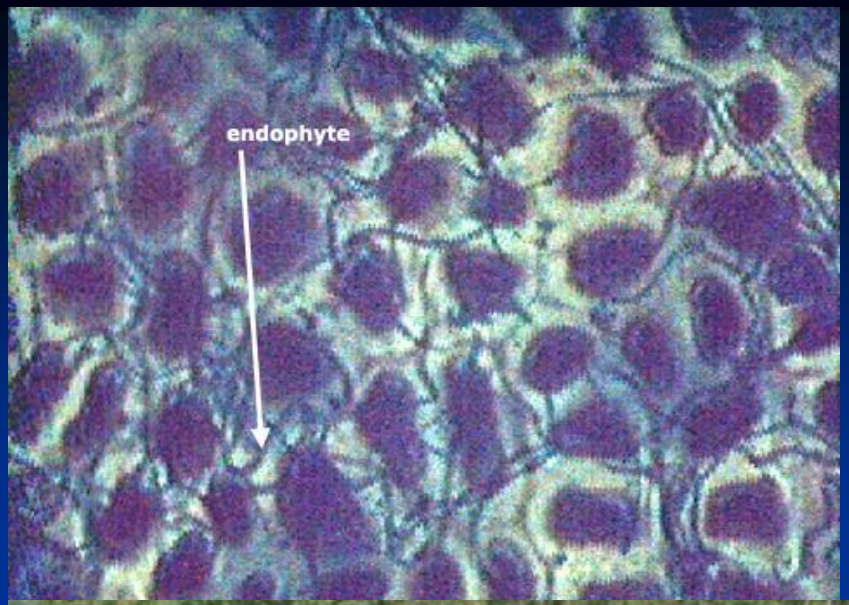
Alkaloids

- Usually basic, bitter & toxic (v. potent)
- eg. Cocaine, nicotine & caffeine
- Animal feed sources
  - Lupins, potatoes contain solanine-based alkaloids
- Effects
  - Kidney, pulmonary & liver damage, diarrhea, vomiting

Ergot Alkaloids & Fescue Toxicosis

- Most pre 80s tall fescue in US infected with endophyte fungi (Neotyphodium coenophialum) that produced ergot alkaloids e.g. clavine alkaloids, lysergic acid amides, and ergopeptines
- Symptoms
  - Vasoconstriction
  - Foot problems
  - Retained winter coat
  - High body temp & respiration
  - Fat Necrosis
  - Reproductive & birthing problems





Images from Roberts & Andrae (2004)
http://www.plantmanagementnetwork.org/pub/cm/management/2004/toxicosis/

Solutions

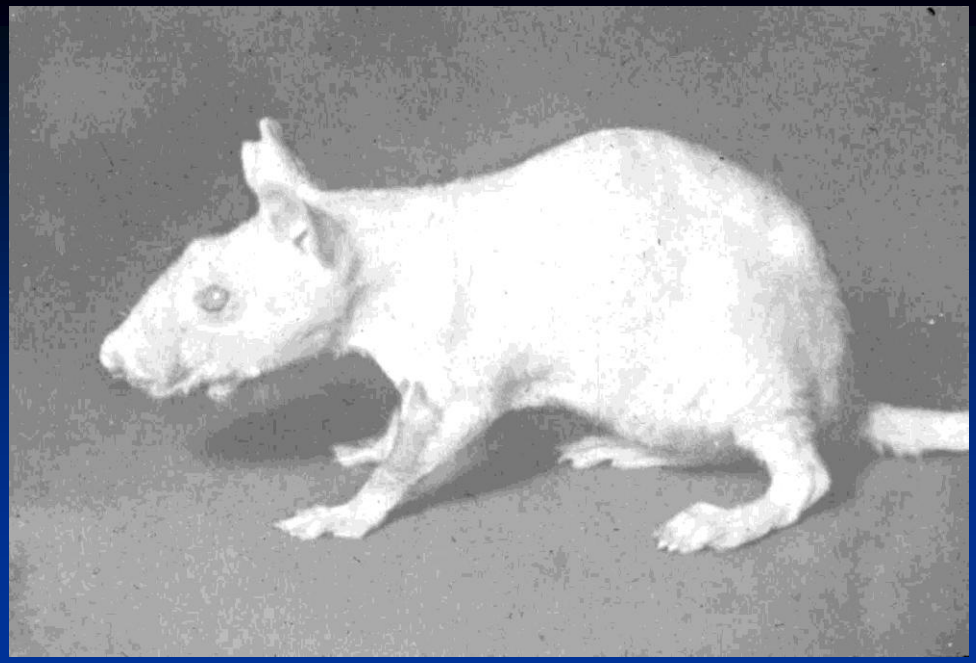
- Dilute pasture with clover or other spp.
- Graze closely
- Plant endophyte-free fescue cultivars
  - No animal health issues and great performance
  - More susceptible to drought, pests, & overgrazing

- Novel / introduced endophyte cultivars
  - Have endophytes but they don't produce ergot alkaloids
  - Overcome problems with endophyte-free cultivars

Non-protein amino acids

Mimosine

- Found in *Leucaena leucocephala (20-30% CP)*
- Metabolic derivative 3,4-DHP (3-hydroxy-4(1H)-pyridone) causes goiter, alopecia, anorexia, gastroenteritis, hepatotoxicity
- R. Jones discovered that Leucaena toxins are inactivated by a rumen microbe (*Synergistis jonesii*) in Hawaii sheep and has introduced cultures
- Florida Senopol (origininated from St Croix) cattle are also resistant to DHP



Alopecia


leucaena leucocephala
© 2004 pictured by antonie van den bos
for aycronto.com

Glucosinolates

- Thioglucose group bound to an amino acid
- Source
  - Linseed
  - Brassica forage crops e.g. kale, rape
- Effect
  - Milk taint, thyrotoxic & goitrogenic

Glucose removal

↓

aglycone residue

↓

toxic derivatives

e.g nitriles
isothiocyanates

Mycotoxins

Name	**Produced by:**
DON	Fusarium moniliforme and F. graminearum (vomitoxin)
T-2	F. sporotrichioides
Zearalenone	F. graminearum
Fumonisin	F. moniliforme
Aflatoxin	A. fumigatus

- Sources – moldy feed, e.g. soybean, barley, spoiled silage

Hemorrhagic bowel syndrome

>2% of deaths of adult cows -increasing/ under-diagnosed (Forsberg, 2004)

Tannins

- Compounds that tan leather
- Polyphenolic plant defense compounds that can form stable complexes with:
  - Proteins
  - Carbohydrates
  - Minerals
- Have beneficial /deleterious effects

- Ubiquitous
  - Grapes/wine, tea, fruit juices, apples/cider, trees

Selected Forage Plants with Tannins

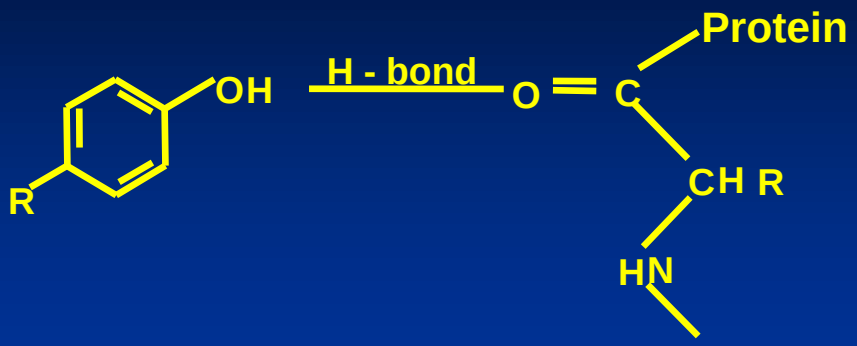
- *Lotus species*
- *Sainfoin*
- *Faba beans*
- *Peas*
- *Sorghum*
- *Calliandra calothyrsus*
- *Leucaena leucocephala*
- *Sesbania sesban*
- *Gliricidia sepium*
- *Acacia species*

- *Content varies*
  - *- 0 % in temperate grasses*
  - *-Low (0-5 %) in most temperate legumes*
  - *-Up to 50 % in tropical browses but less than 5% in some tropical legumes*

Types

Phlorotannins	Hydrolyzable tannins/ Anthocyanidins	Condensed tannins / Proanthocyanidins (PAs)
Least complex Least known Brown algae	Susceptible to enzymic & non-enzymic hydrolysis V. Water soluble Can be toxic	Most widespread Typical plant tannins Less toxic

PAs affect forage utilization by:



- Forming strong H bonds with with nutrients
- Inhibition of digestive enzymes
- Inhibition of rumen microbial activity
- Concentrations of 2-4% of DM increase N utilization due to increased bypass
- Concentrations >7% usually reduce nutrient utilization

Effect of PAs depends on:

- **Proanthocyanidins**
  - **Concentration**
  - **Properties**
    - Molecular weight
    - Degree of polymerisation
- **Proteins**
  - **Concentration**
  - **Properties**
    - Size of polymers
    - Chemical structure
    - Richness in proline

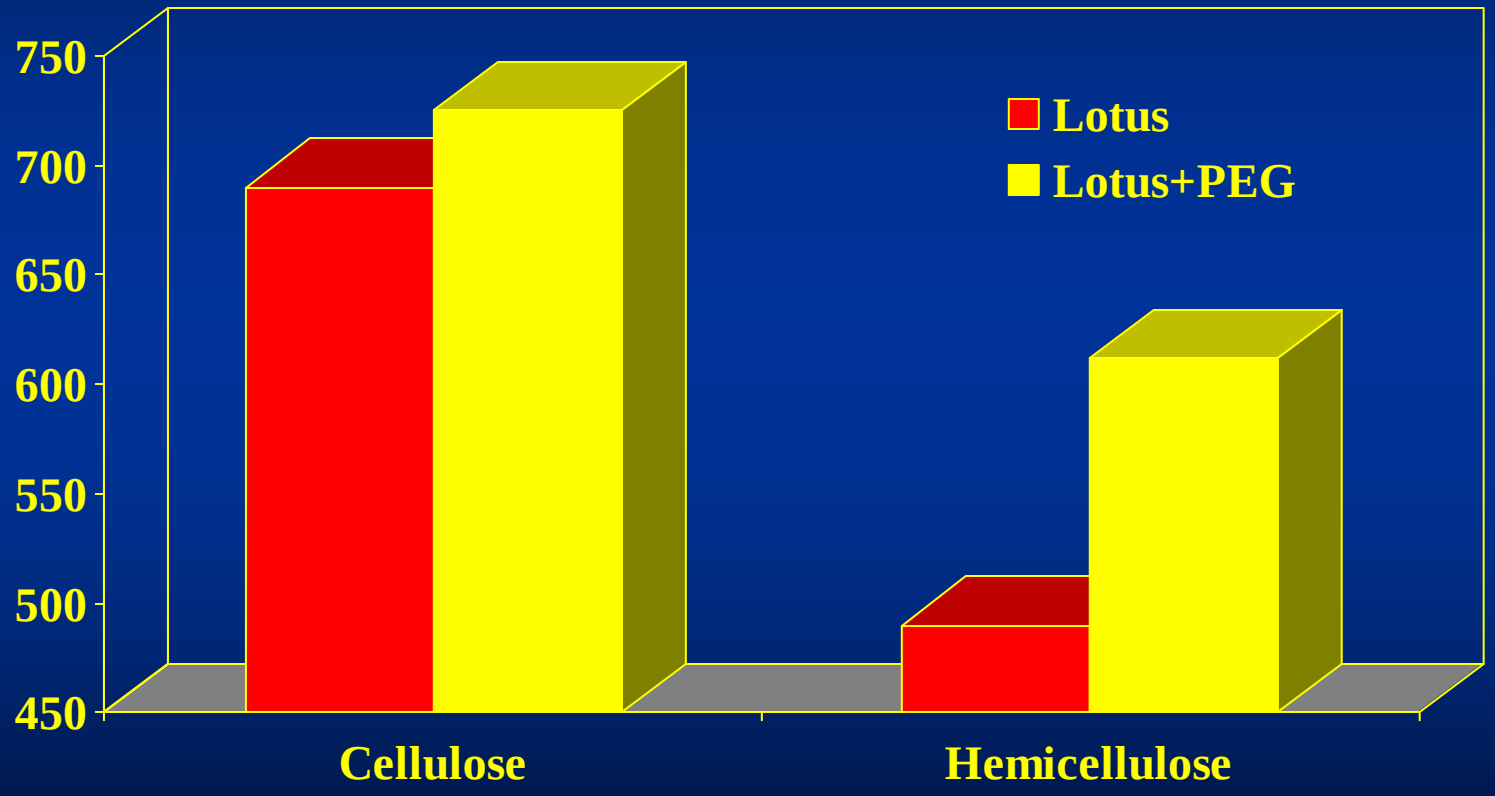
- **Animal spp**

Proline-rich proteins abundance /tannin tolerance :

deer> goat> sheep> cattle

- **pH**
- **Tannin-binding agents**
- E.g PVP, PEG, proline rich proteins

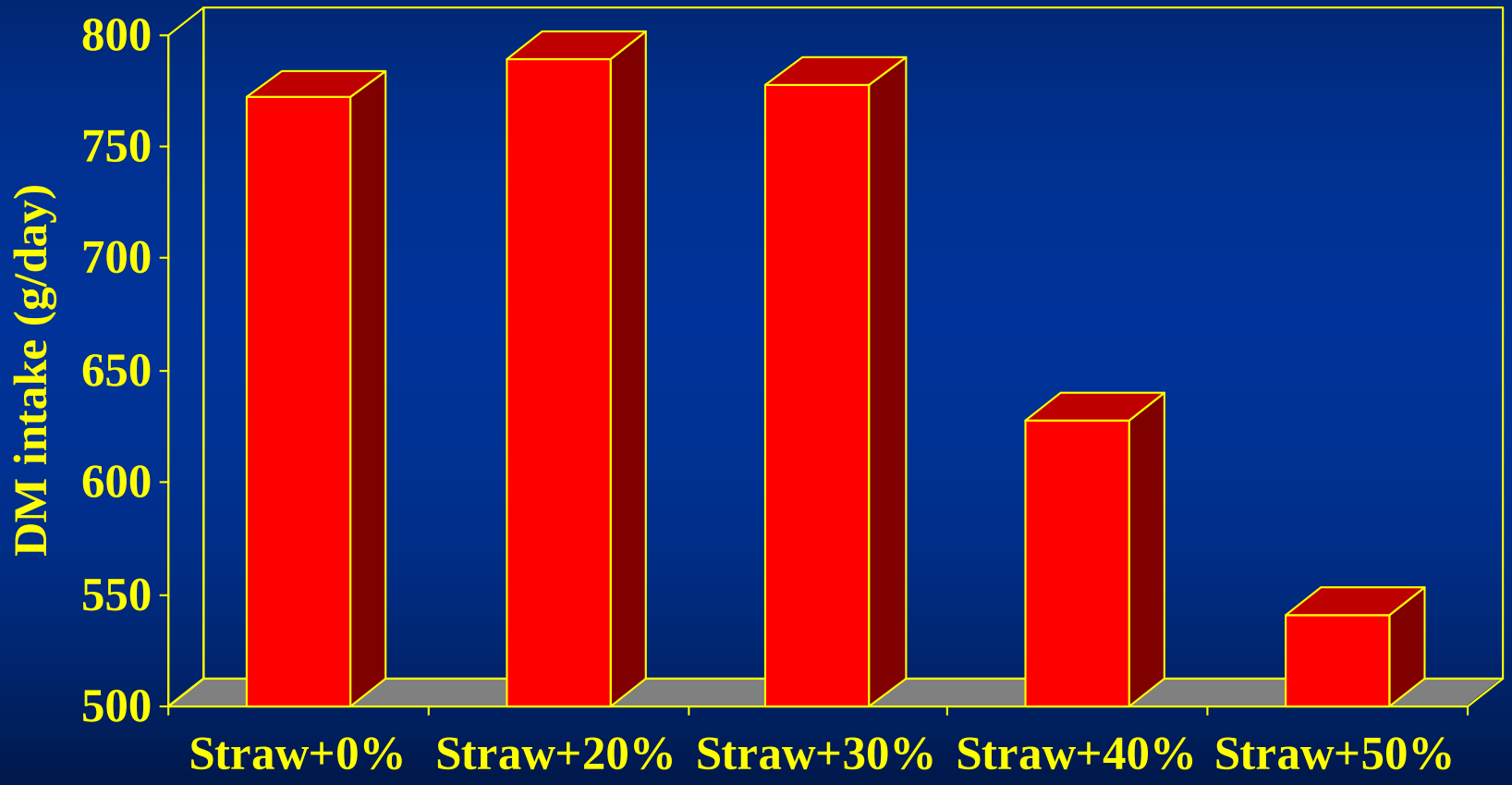
Effect of tannins on rumen digestibility of cellulose and hemicellulose



Effect of PAs on forage quality

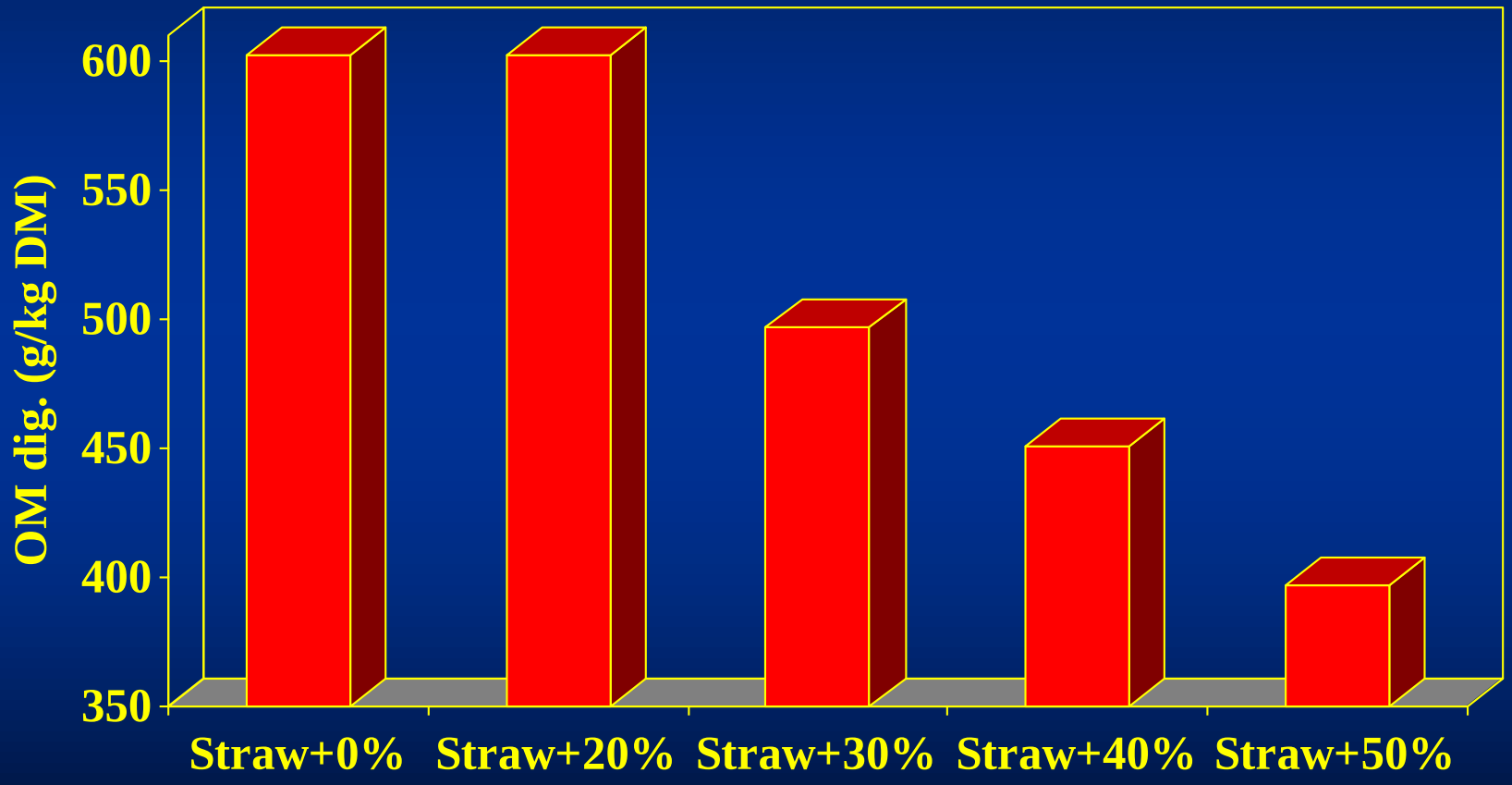
- **Negative**
  - Reduction in VFI
    - Astringent
  - Reduction in digestibility
  - Erosion of GIT lining
  - Toxicity – HT
- **Positive**
  - Increased efficiency of protein utilisation
  - Reduction of parasite burden
  - Reduction of proteolysis during ensilage
  - Bloat prevention
  - Increase quality of animal products
  - Reduction of N emission into the environment
  - Defaunate rumen

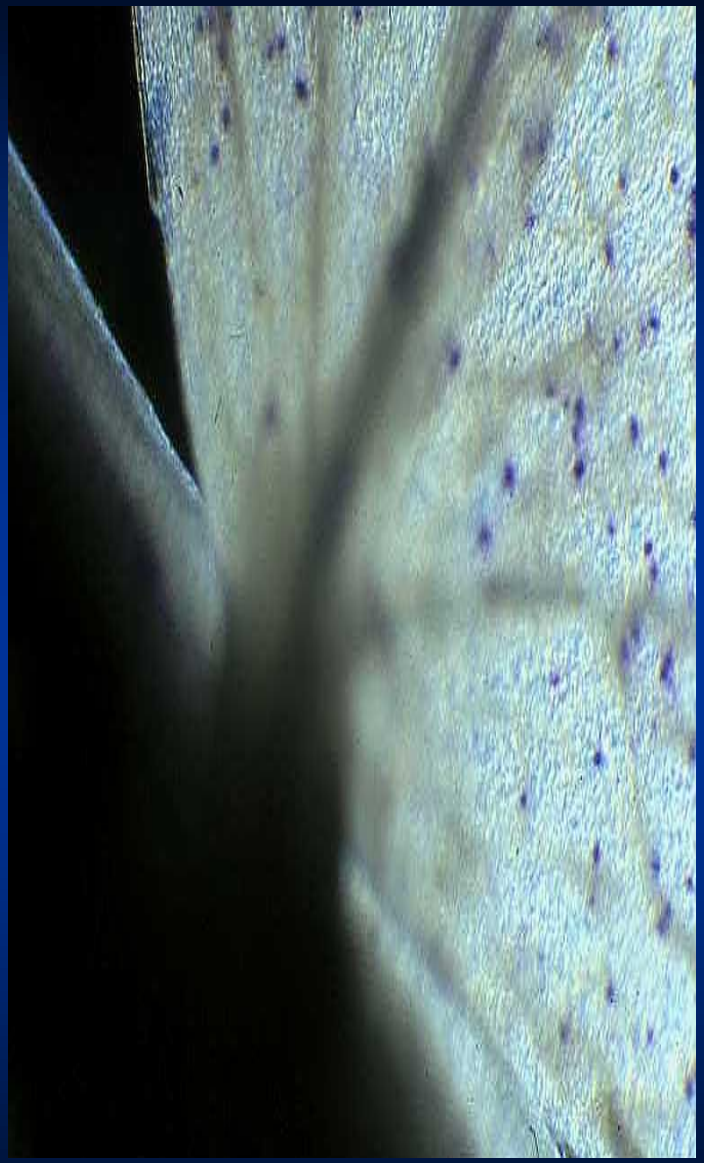
DM intake of sheep fed straw & increasing levels of *Calliandra* (22% CP; 10% tannins)



(Salawu, 1996)

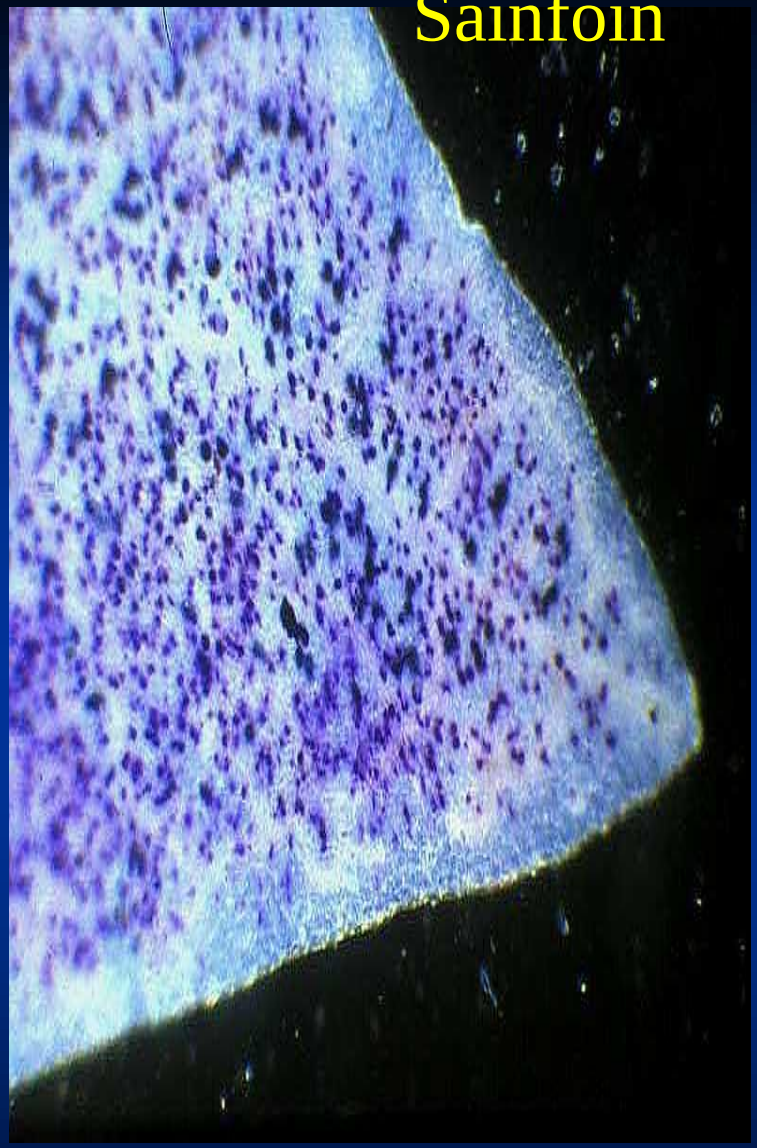
OM digestibility of sheep fed Straw + increasing levels of *Calliandra*



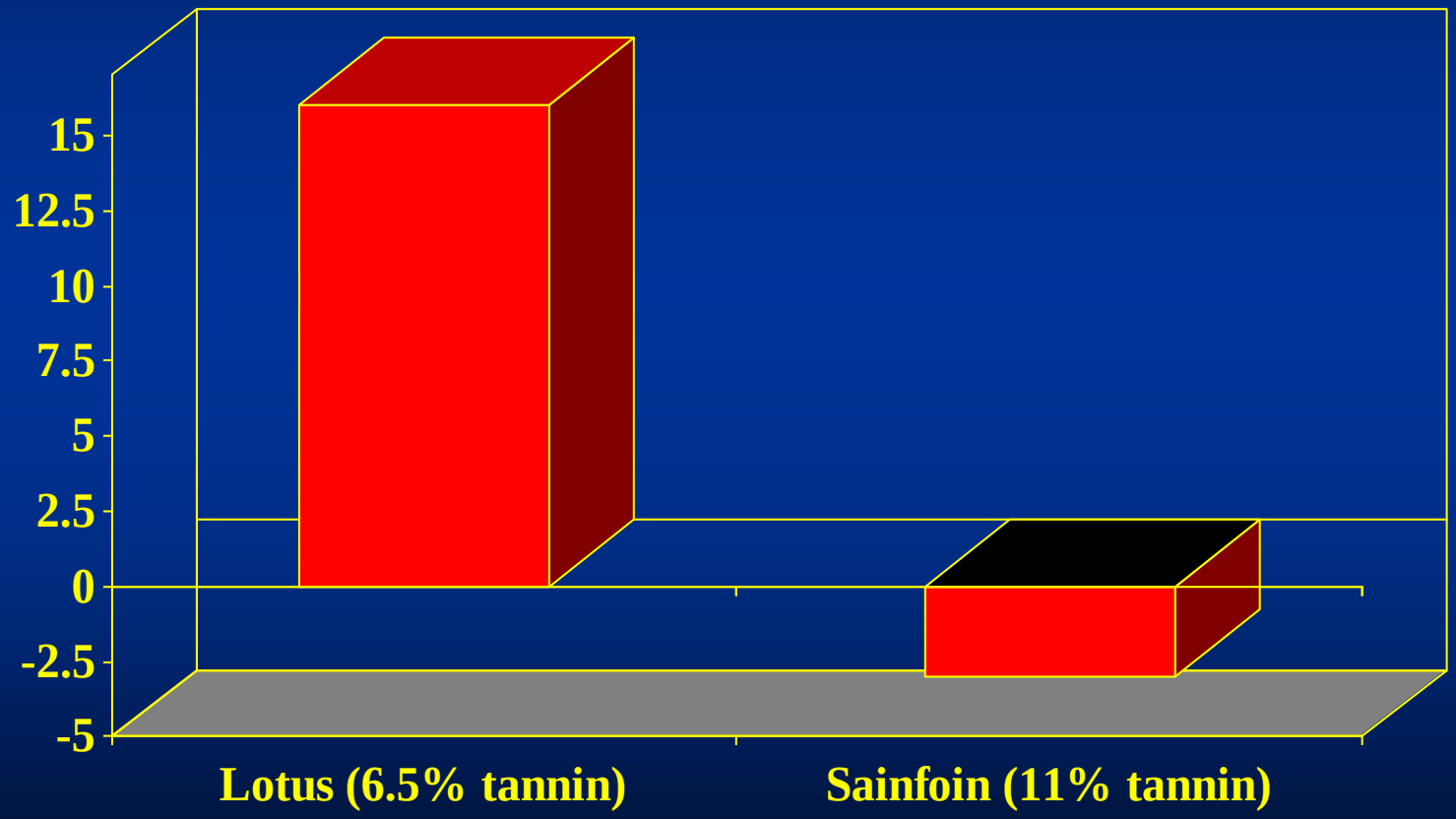


Lotus

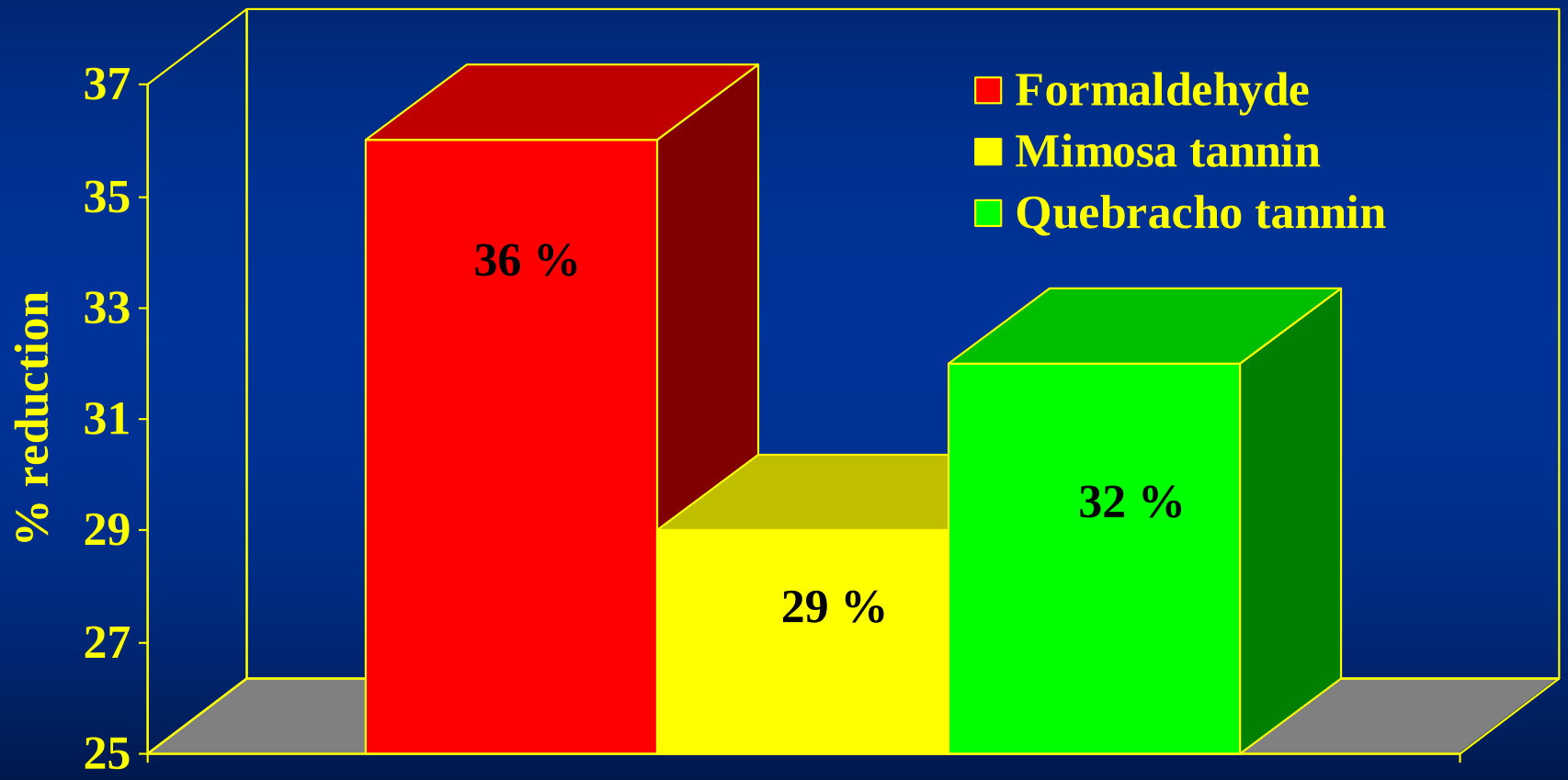
Sainfoin



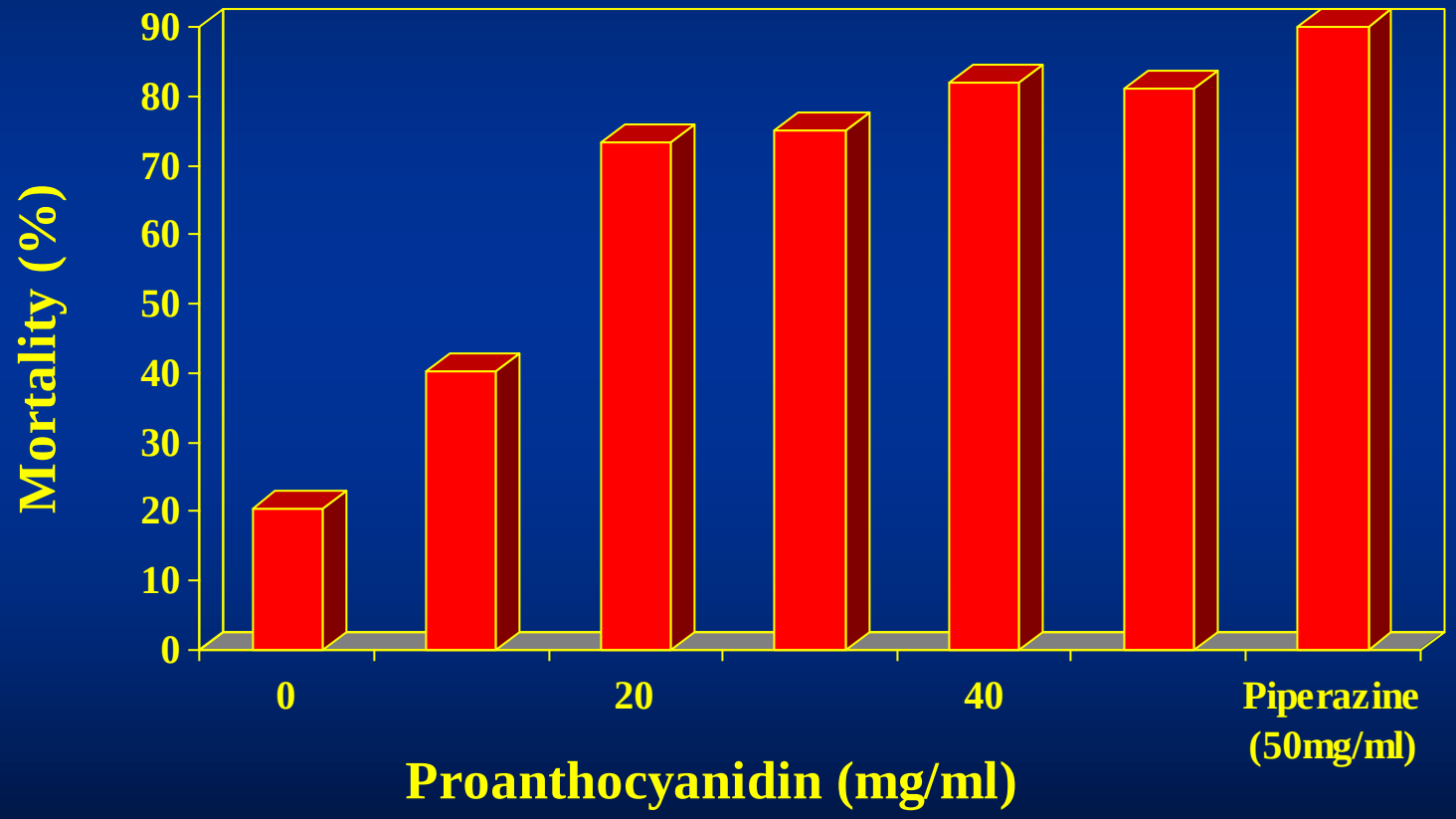
N-balance in sheep fed different legume forages



Tannins as silage inoculants: Protein protection during ensilage



Effect of PAs and anthelmintics on infective larvae of *H.contorus*



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