Tannins in the nutrition of wild herbivores
Tannins are feeding deterrents. They occur in browse (leaves). They deter feeding by reducing digestive efficiency and by toxicity.
Mortalities in kudu (*Tragelaphus strepsiceros*) populations related to chemical defence in trees

Wouter van HOVEN

![Graph](graph.png)
Figure 6. A summary of actions, effects, and counter-adaptations of plant secondary metabolites (PSM) in mammalian herbivores.

from Foley et al. (1999)
**Figure 1.** Relationships between feeding niche, diet, amount, and diversity of plant secondary metabolites (PSM) eaten, and the physiological capacity of the herbivore to deal with them.

*from Foley et al. (1999)*
How plants fight back

Eating plants is all about predators making easy meals of passive greenery—or is it? Plants have evolved ways of discouraging those who would eat them.

Stephen Young

Trees can communicate with each other

Can one tree warn another tree that it is about to be eaten? It would seem so.

Trees’ secret warning system against browsers

Prof. Wouter van Hoven
University of Pretoria
Condensed tannin as anti-defoliate agent against browsing by giraffe (*Giraffa camelopardalis*) in the Kruger National Park

D. Furstenburg and W. van Hoven
Figure 5. Proposed series of steps in a mammalian herbivore that may enable feedback leading to a decision to either eat or not eat a particular plant food.

from Foley et al. (1999)
<table>
<thead>
<tr>
<th>Animal</th>
<th>Eat Tannins?</th>
<th>References</th>
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</table>

All these animals will try to minimize tannin intake. However, most cannot avoid them completely!

Tannins are part of the natural diet of many animals.
TANNIN-BINDING PROTEINS IN SALIVA OF DEER AND THEIR ABSENCE IN SALIVA OF SHEEP AND CATTLE

PAUL J. AUSTIN, LISA A. SUCHAR, CHARLES T. ROBBINS, and ANN E. HAGERMAN

Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system* ***

R.R. Hofmann

---

* Concentrate Selectors
  - Roe deer
  - White-tailed deer
  - Red Duiker

** Grass and Roughage Eaters (high fibre)
  - Moufflon
  - Topi antelope (Tiang, Tsesebe)
  - Range cattle

---

Peroxid
0.22 % of BW

---

Peroxid
0.05 %

---

Peroxid
0.18 %

---

Peroxid
0.22 %

---

Peroxid
0.07 %

---

Peroxid
0.06 %

---

* ***
## Salivary tannin-binding proteins

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<tr>
<th>Species</th>
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<tr>
<td>Swamp wallabies (<em>W. bicolor</em>)</td>
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<td>Pademelon (<em>Thylagale thetis</em>)</td>
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<td>Mouse (<em>Mus musculus</em>)</td>
<td>Mehansho et al. (1985), Asquith et al. (1985)</td>
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<td>Rat (<em>Rattus norvegicus</em>)</td>
<td>Mehansho et al. (1983), Jansman et al. (1994)</td>
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<td>Root vole (<em>Microtus oeconomus</em>)</td>
<td>Juntheikki et al. (1996)</td>
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<td>Beaver (<em>Castor canadensis</em>)</td>
<td>Hagerman and Robbins (1993)</td>
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<td>Pika (<em>Ochotona princeps</em>)</td>
<td>Dearing (1997)</td>
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<td>Rabbit (<em>Oryctolagus cuniculus</em>)</td>
<td>Mole et al. (1990)</td>
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<td>Hare (<em>Lepus timidus</em>)</td>
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<td>Black bear (<em>Ursus americanus</em>)</td>
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<td>Camel (<em>Camelus dromedarius</em>)</td>
<td>Schmidt-Witty et al. (1994)</td>
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<td>Roe deer (<em>Capreolus capreolus</em>)</td>
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<tr>
<td>White-tailed deer (<em>Odocoileus virginianus</em>)</td>
<td>Robbins et al. (1987b), Mole et al. (1990)</td>
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</table>
Salivary tannin-binding proteins in rhinos

from Clauss et al. (subm.)
Salivary tannin-binding proteins in black rhinos

from Clauss et al. (subm.)
Tannin chemistry in relation to digestion

ANN E. HAGERMAN, CHARLES T. ROBBINS, YOHAN WEERASURIYA, THOMAS C. WILSON, CLARE MCArTHUR

MULE DEER

DOMESTIC SHEEP

DIGESTIBLE PROTEIN CONTENT
(g/100g Feed)

QUEBRACHO

QUEBRACHO

TANNIC ACID

TANNIC ACID

DIETARY TANNIN CONTENT (%)
VARIATION IN MAMMALIAN PHYSIOLOGICAL RESPONSES TO A
CONDENSED TANNIN AND ITS ECOLOGICAL IMPLICATIONS

Flavonoids and tannins: plant-based antioxidants with vitamin character

A. Hässig, W. X. Liang, H. Schwabl, K. Stampfl


The Flavonoids. A Class of Semi-Essential Food Components: Their Role in Human Nutrition

Joachim Kühnau
Flavonoid Intake and Long-term Risk of Coronary Heart Disease and Cancer in the Seven Countries Study

Michael J. L. Hertog, PhD; Daan Kromhout, PhD; Christ Aravanis, MD; Henry Blackburn, MD; Ratko Buyk, MD; Flaminio Fidanza, MD; Simona Giampaoli, MD; Anne Marie Jansen, MD; Alessandro Mencati, MD; Sreko Nedeljovic, MD; Majja Pelkourinen, PhD; Bettina S. Sinic, MD; Hironari Tashima, MD; Edith J. M. Feskens, PhD; Peter C. H. Hollman, MSc; Martijn B. Katan, PhD

Flavonoid intake and coronary mortality in Finland: a cohort study

Paul Knekt, Riku Järvinen, Anni Reunanen, Jouko Miettinen

Association of Serum Lipoproteins and Health-Related Habits with Coffee and Tea Consumption in Free-Living Subjects Examined in the Israeli CORODIS Study

Manfred S. Green, M.D., Ph.D.; and Gil Harari, B.Sc.

Coffee and tea consumption and the prevalence of coronary heart disease in men and women: results from the Scottish Heart Health Study

C A. Brown, C Bolton-Smith, M Woodward, H Tunstall-Pedoe

Dietary antioxidant flavonoids and risk of coronary heart disease: the Zutphen Elderly Study

Michael J L Hertog, Edith J M Feskens, Peter C H Hollman, Martijn B Katan, Daan Kromhout

Antioxidant flavonols and ischemic heart disease in a Welsh population of men: the Caerphilly Study

Michael J L Hertog, Peter M Sweetman, Ann M Fehily, Peter C Elwood, and Daan Kromhout

Wine, alcohol, platelets, and the French paradox for coronary heart disease

S Renaud, M De Lorgeril
Tannins can function as antioxidants.

Phenolic substance can be absorbed from the gut and support other antioxidants within the body.

Even if not absorbed, phenolic substances can protect other antioxidants from being oxidized in the gut and thereby increase their availability.
Black rhino feeding trials

from Clauss et al. (in prep.)
In several captive animal species, low antioxidant status has been reported.

Roe deer have been suspected to be dependent on vitamin C intake in captivity. Enteritic disorders in roe deer have been cured by high dosages of vitamin C alone.
Tannins prevent bloat.
Do foregut-fermenting arboreal folivores depend on tannins to prevent bloat and control intestinal bacteria and parasites?
Tannins have anthelmintic properties.
Antiparasitic Effect of Tannins

tannin-containing browse

low fecal egg count

from Kabasa et al. (1999)

tannin-containing browse + tannin-inactivating PEG

high fecal egg count
Tannins have antibacterial properties against a wide range of bacteria, including potential gastrointestinal pathogens.
Causes of Mortality in 30 Roe Deer (*Capreolus capreolus*) at the Field Research Station Niederfinow

- **Enteritis**: 63%
- **Physical Damage**: 20%
- **Other**: 17%
Causes of Mortality in 131 Moose (Alces alces) in German Zoos & Wildlife Parks

- Wasting-Syndrome-Complex: 47%
- Intraspecific Aggression: 13%
- Malignant Catarrhal Fever: 12%
- Other Infections: 8%
- Bladder Tumor: 5%
- Other: 15%
Are browsing ruminants dependent on phenolic plant substances for their antioxidant supply and/or intestinal parasite and bacteria control?
If so, by what mechanisms did grazing ruminants become independent of phenolic plant substances?
Tannins reduce the availability of dietary iron.
Pathogenesis of Hemosiderosis in Lemurs: Role of Dietary Iron, Tannin, and Ascorbic Acid

Lucy H. Spelman, Kent G. Osborn, and Marilyn P. Anderson

Department of Pathology, Center for Reproduction of Endangered Species, Zoological Society of San Diego, San Diego, California
ROLE OF CHRONIC IRON OVERLOAD IN MULTIPLE DISORDERS OF CAPTIVE BLACK RHINOCEROSES (Diceros bicornis)

Donald E. Paglia, MD\(^1\)* and Pam Dennis, DVM\(^2\)

\(^1\)Hematology Research Laboratory, Department of Pathology & Laboratory Medicine, UCLA School of Medicine, 10833 LeConte Avenue, Los Angeles CA 90095-1732 USA; \(^2\)Department of Wildlife and Zoological Medicine, University of Florida College of Veterinary Medicine, PO Box 100126, Gainesville FL 32610 USA
Did some hindgut-fermenting browsers develop especially effective iron absorption mechanisms to compensate for the chelating effects of dietary tannins?
Is there a tannin “requirement” for certain species?
What's in a (free-ranging) roe deer's diet?

from Tixier et al. (1997)
ROE DEER CHOOSE TO INCLUDE SMALL AMOUNTS OF TANNINS IN THEIR DIET

Hélène VERHEYDEN-TIXIER¹, Patrick DUNCAN² and Nadine GUILLON²
Roe deer preference trials

from Clauss et al. (2003)
Roe deer preference trials

from Clauss et al. (2003)
Roe deer preference trials

from Clauss et al. (2003)
Roe deer preference trials

from Clauss et al. (2003)
Roe deer preference trials

from Clauss et al. (2003)
Giraffe preference trials

from Clauss et al. (2002)
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from Clauss et al. (2002)
Giraffe preference trials

from Clauss et al. (2002)
Roe deer feeding trials

from Clauss et al. (2003)
Roe deer feeding trials

from Clauss et al. (2003)
Roe deer feeding trials

pelleted diet

from Clauss et al. (2003)
Roe deer feeding trials

pelleted diet

regular

3% tannic acid

from Clauss et al. (2003)
Roe deer feeding trials

Pelleted diet

Regular

3% tannic acid

Food intake per group (g)

Control group

Tannin group

from Clauss et al. (2003)
Roe deer feeding trials

pelleted diet

regular

3% tannic acid

Body weight gain (%)

from Clauss et al. (2003)
Low levels of dietary tannins can prevent protein/carbohydrate degradation in the forestomach, thus enhancing their nutritive value for ruminants.

In sheep, Kaitho et al. (1998) even reported weight gains due to the use of tannins.
Conclusions?

• Low levels of tannins might be beneficial for many captive wild animals (based on theoretical considerations)

• Many potentially tannin-related problems in captivity could possibly be solved by a more restricted use of concentrate feeds, by an increase in fibre content, by controlled mineral levels

• As always: more research needed …
end of session