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Browse silage: the future for browsers in wintertime?

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Hoffman and Stewart (1972) made the classic differentiation of ruminants between browser ('concentrate selectors'), intermediate feeders and grazers. The group browsers is a heterogeneous group, consisting of fruit eating animals with a high degree of herbaceous dicotyledons in their diet and tree shrub leaf eating animals. Several diseases in browsing ruminants are linked to an inadequate nutrition (Clauss *et al.* 2003). Examples of browsing ruminants are given in Table 1.

Table 1: Overview of browsing ruminants (adapted from Hofmann 1988, 1991)

Bongo	Giraffe	Roe Deer
Bushbucj	Greater kudu	Suni
Chinese Water Deer	Lesser kudu	Tufted Deer
Dikdik	Mule Deer	White Tailed Deer
Duikers	Moose	
Gerenuk	Okapi	

Differences between browsers and grazers

The diet and digestion of browsers are different compared to grazers (reviewed with detailed references in Clauss *et al.* 2003):

- Browse can contain a high amount of secondary plant compounds;
- Average browse has a different nutrient composition to grass, particularly with respect to the fibre composition;

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- Grazers have a rumen stratification; browsers do not when properly fed;
- In browsers, the rumen passage rate is faster than in grazers and they have less selective particle retention in the rumen;
- Browsers have less fibre digestion and more nutrients reach the small intestines unfermented;
- Particles leaving the rumen of browsers are of a bigger size than those leaving the rumen of a grazer.

Browse feeding in zoos

When browsers are maintained in zoos, it is a huge task to supply them with enough browse. As well as problems with harvesting and logistics, the most important question is whether enough browse can be obtained during the whole year. In tropical areas, there should be enough browse to feed all the year around. But in temperate areas, especially in the late autumn, during wintertime, and the beginning of spring, it is difficult to provide enough fresh browse. Ways should be found to supply an adequate amount of browse. Browse can be conserved in three ways:

Freezing

The leaves and twigs have to be deep-frozen fast. In order to prevent freeze-drying and oxidation of the product, the best way is to pack the browse airtight. The temperature of the freezer should be at least min 15 °C centigrade. For many animals, the defrosted browse is not palatable. Also, the freezing and storing process costs a lot of money.

Drying

Natural drying of browse depends on the weather. However, drying should be fast, in order to prevent the development of mould and fungi. Artificial drying is preferred; the result is a more palatable product. Dried browse leaves can be bought from several companies, although it is expensive. Dried browse should not be exposed to sunlight. Contamination with pests like rats, mice and birds while storing should be prevented. The palatability of the product will decline after drying.

Silage

Silage is the term used when forage with a high moisture content is preserved by fermentation. The main principle of preservation as silage is the rapid establishment of a low pH by lactic acid fermentation, and the maintenance of anaerobic conditions. After six to eight weeks, the product has reached a pH of about 4.2, after which the process stops. When the pH is higher, butyric acid is produced, which can easily be smelled. When the product is too dry, fungi can develop. The dry matter of the original product should be about 40–45 % (Driehuis 2000).

The ensiling process can be divided into four phases (Driehuis 2000):

Aerobic phase

During this period, the atmospheric oxygen is trapped in the ensiled mass, and readily reduced due to the respiratory activity of plant material and aerobic or facultative aerobic bacteria.

Fermentation or acidification phase

During this phase, different groups of micro-organisms, capable of anaerobic growth, like lactic acid bacteria, enterobacteria, clostridia and yeast compete for available nutrients. In well-preserved silage, lactic acid bacteria will rapidly dominate the fermentation process, and will result in a decrease in pH due to the accumulation of lactic acid, and to a lesser extent of acetic acid formed from sugars, mainly glucose, fructose and sucrose.

Storage phase

This phase usually lasts from several weeks to a year, or longer. As long as the pH is sufficiently low and penetration of air into the silage is excluded, relatively little change occurs during this phase. In this phase, bacteria like bacilli and clostridia can survive as spores. Other bacteria, such as *Lactobacillus buchneri*, continue to be active at a low level. During the fermentation and storage periods, a part of the protein fraction is degraded to peptides, amino acids, amines and ammonia by enzymes of plant and microbial origin.

Aerobic deterioration

When fed, the silage is exposed to air. Exposure to air also can occur by damaging the silage wrappping. Micro-organism like yeasts and acetic acid bacteria then oxidize the preservative acid present in silage. As this process proceeds, the pH rises and other aerobic micro-organisms start to proliferate. In the majority of silages, lactic acid bacteria grow best between 20 and 40°C, with an optimum at 30 °C. In order to prevent growth of unwanted bacteria, the pH should rapidly decrease, and all oxygen should be excluded. Fermentation-controlling additives can be added to improve the fermentation process. If the conditions of the silage are not well, undesirable micro-organism can grow, for example *Listeria*, *Bacilli* and *Clostridium* species as well as several species of yeast, moults and *Enterobactericeae* (*E. coli O157*).

Zurich method

Hatt and Clauss (2001) described in EAZA News Special Issue on Zoo Nutrition II how silage is made at Zurich zoo. Leaves and twigs of willow, hazel and maple are processed in a chaff cutter and then stored under pressure in 200 litter plastic containers, air-tightened and stored at a temperature not above 20 °C. After six months, it is fed to their black rhinos. These authors also analysed the browse before and after the silaging process. The analyses did not show a significant alteration in composition before and after silaging.

Rotterdam method

In the autumn of 2001, Rotterdam Zoo started harvesting willow browse. The cut willow branches were about 1 meter long, and the diameter of the branches were 1 to 2 cm. The willow branches were bailed through a bailing machine, under similar pressure as hay being bailed. The bales were double wrapped in plastic and the dimensions were 100 × 50 × 35 cm, and weighted between 45 and 50 kg. Due to the pressure of the bailing machine and the plastic wrapping machine, most air was excluded from the willow bales. Every bale had to be checked to ensure no branches pierced the plastic wrap. All holes were repaired using plastic tape. During the first few weeks, the remaining oxygen produced inside the bales caused anaerobic growth. At this time, the bales appeared swollen. When the oxygen level in the bales subsequently declined, anaerobic bacteria started growing and consumed the gas. After six to eight weeks, the process ceased and as so much of the gas had been consumed, the willow in the bales was in a vacuum. Because there is a surplus of willow in the area of Rotterdam, mainly willow (*Salix alba*) was processed, although some poplar (*Populus canadensis*) browse was silaged as well. A total of 70 willow bales and 15 poplar bales were prepared. The silage was fed to the browsers in Rotterdam during winter. Each browser received 0.5 kg a day. The palatability of the fed silage browse was compared to frozen browse. All browsers (okapis, giraffes, kudus, tufted deer and bongos) showed a preference for the browse silage and the palatability (J. Nijboer: pers. obs.) was much better than the frozen browse. Even the branches were eaten! There is a great potential in feeding silage browse to browsers and probably also to intermediate feeders. However, more research is needed.

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