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SUMMARY OF DOCTORAL THESIS

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Title: Evaluation of the Associative Effects of Mixing Kenyan Tree Browse Foliages and Yeast Supplementation on Digestion in ruminants

(ケニア在来飼料木本葉部の混合および酵母添加が反芻家畜消化率向上に及ぼす影響)

Foliage from multipurpose tree (MPT) and shrubs is an important feed resource in arid and semi-arid areas of Kenya. Past research efforts have focused on identification and evaluation of single species and utilisation of polyethylene glycol (PEG) to deactivate the phenolic compounds known to depress nutrient digestibility and voluntary feed intake. PEG is expensive and unavailable at farm level hence the need for cheaper alternatives. The few studies conducted on utilisation of browse leaf mixtures have failed to enumerate the effects of mixing on associative effects (AE) known to occur when feed ingredients are mixed. The research was therefore conducted to quantify the occurrence of AE from browse mixing and explore potential of yeast to influence rumen digestion of selected tanniniferous foliages from Kenya.

Three *in vitro* experiments and an *in vivo* animal trial were conducted to measure the effects of the two strategies. Leaves from *Acacia brevispica*, *Acacia elatior*, *Accacia mellifera*, *Balanites aegyptiaca*, *Berchemia discolor*, *Grewia bicolor* and *Zizyphus mucronata* were used in the studies. The first experiment was conducted to determine the effect of Japanese Sake yeast (JSY) and bioethanol residue yeast (BRY) on the *in vitro* rumen DM digestibility (IVRDMD). The second study tested the rumen fermentability and potential nutritive value of foliage mixtures using the *in vitro* gas production technique. The extent of DM digestibility on different sites of the gastrointestinal tract was measured in the third study using the *in vitro* three-step digestion procedure. The final study was an *in vivo* digestion trial using growing goats in Kenya to measure the effects of browse mixing on nutrient digestibility and animal performance.

Incubation with yeast supplements increased the IVRDMD of browse foliages. Variability in the IVRDMD was because of the supplements ($P < 0.05$) and browse foliages ($P < 0.05$). The JSY supplement had significantly higher IVRDMD than the BRY and soybean peptide supplements ($P < 0.05$). *Berchemia discolor* had significantly higher IVRDMD in response to all the supplements, while *G. bicolor* had the least response respectively ($P < 0.05$). Ability of yeast to degrade browse foliages was dependent on strain while chemical composition especially the tannin content influenced the differences between browse foliages. The study showed that *B. discolor* and JSY had good rumen fermentation characteristics and feed value upgrading potential, respectively. The two were chosen as the principle components on which subsequent mixture studies were conducted. The study also showed that yeast had potential to

attenuate the antinutritive effects of tannins in browse foliages on the rumen fermentation by providing microbial yeast protein and promoting growth and activity of fibre digesting microbes.

In the second experiment, six browse mixtures were prepared by mixing one part of *B. discolor* with one part of *A. brevispica*, *A. elatior*, *A. mellifera*, *B. aegyptiaca*, *G. bicolor* and *Z. mucronata*. Browse mixing and JSY supplement addition increased gas production volume, maximum gas production rate and induced positive AE in the same parameters ($P < 0.05$). Time to reach maximum gas production rate was lower in browse mixtures compared to single species and was shortened by PEG addition ($P < 0.05$) as compared to JSY addition. It was suggested that browse mixing provided more potentially fermentable material than single browses and could dilute the negative effects of tannins on digestion. Yeast protein offered a plausible binding site for tannins in addition to promoting rumen microbial growth and fermentation hence upgrading the *in vitro* ruminal digestion of tropical browses.

Browse mixing increased the *in vitro* rumen (IVRDMD), lower tract (IVLTDMD) and total tract (TTDMD) in study three. The effect of PEG on IVRDMD was higher in single browses but browse mixing diminished the effectiveness of PEG in browse mixtures. Addition of JSY and PEG did not increase the IVLTDMD in browse mixtures but in single species, JSY addition had a positive increment on IVLTDMD. The negative AE at the ruminal level were reversed at the intestinal level. The study revealed that effects of JSY and PEG addition were dominant at the ruminal level but not at the intestinal level. The high digestibilities of mixtures and appearance of positive AE at intestinal level compared to single foliages may be tapped into to support higher levels of production in ruminants.

In the last experiment, growing goats were fed a control diet of Rhodesgrass hay (RH) with maize germ (MG). The other treatments consisted of the control diet supplemented with 0.9 % BW of dried *B. aegyptiaca* (Balanites), *Boscia angustifolia* (Boscia) or a mixture of Balanites + Boscia (browse mixture) at a ratio of 1:1. The multipurpose tree (MPT) foliages contained moderate NDF (30- 51 %) and CP (11.1- 12.5 %), whereas RH had high NDF (62.9 %) and low CP (3.5 %). Supplementation with MPT reduced the DM intake (DMI) of RH but total DM intake remained constant. The DMI of RH was significantly reduced in Boscia treatment compared to control ($P < 0.05$). The proportion of N consumed, retained and absorbed was higher in the browse mixture compared to single species supplementation. The DM and N digestibility were higher in browse mixture compared to single species values and significantly differed from the control group ($P < 0.05$). It was concluded that the limitations imposed on feed intake and nutrient digestibility by high fibre contents in Boscia could be alleviated by supplementing the foliage as a mixture with Balanites.

The studies showed that mixing of browse foliages elevated the rumen fermentability of the browse mixtures by allowing a balance in the energy, protein and mineral contents often imbalanced in single species. Feeding of browse foliage mixtures also diluted the negative effects of tannins and other secondary compounds on the process of nutrients digestion. Upgrading of browse mixtures was further achieved by addition of yeast supplement. Metabolisation of yeast in the rumen was postulated to have yielded organic acids, peptides and enzymes that promoted rumen microbial growth and fermentation. Yeast, being a protein, may have also formed bonds with tannins hence upgrading the *in vitro* ruminal digestion of tropical browses. The scope of the study however, could not quantify the binding capacity of yeast protein to tannins hence more studies are needed.