Conclusions

Phytochemical results indicate the predominance of the phenolic class compounds in the three vegetal resources tested. The anthelmintic effect observed *in vitro* in this experiment encourages conducting some studies *in vivo* with further studies on active compounds.

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Exploration and design of alternative feeding systems for livestock in the tropics by integrative system approaches

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Trends in cultivation of cereals and soy bean

The use of cereals and soy meal, a by-product of oil production, as livestock feeds has increased tremendously during the last decades, and is expected to continue to grow. The increase in the supply of these feeds results from increases in both the productivity per area and the expansion of the cultivated area. Further increases in the productivity are possible, but in many situations in the tropics, constrained by lack of access to resources and technologies such as fertilizers, improved cultivars and water.

Impact on the environment

The negative impacts of these trends on the environment are related to the expansion of the cultivated area leading to destruction and fragmentation of ecosystems on fertile soils, and the cultivation in monocultures with high rates of fertilizer and pesticide application. Moreover, the intensive livestock production systems in which these feeds are used have severe additional detrimental effects to the environment, resulting from the application of pesticides, hormones and antibiotics, and the concentration of nutrients resulting in pollution of soils, water and air.

Some possible alternatives

In land-based ruminant production systems, a large potential exists for improved forage supply by restoration and sustainable management of grasslands, better management practices on crop lands, and the introduction of new plant types such as herbal and tree legumes. However, the realization of this potential is constrained by limitations in the resource endowment of many farmers. The production of meat from monogastric animals (poultry, pigs) is increasingly concentrated in large processing units and integrated into industrial supply chains. Such pork and poultry systems could benefit from responsible utilization of urban food wastes, agro-industrial by-products and non-conventional feed resources. In general, more sustainable development pathways could be reached when livestock production is reconnected to the land (and the people), either physically or through policies. Promising archetypes include mixed farming systems and urban agriculture.

Criteria for alternative feeding systems

Development of new feeding systems should originate from an integrated systems-oriented perspective on feed supply within the farm context, and the farm within the regional and higher scale settings. Moreover, long term concerns such as build-up of soil fertility should be explicitly included. Thus, multiple spatial and temporal scales should be addressed when developing new livestock production systems. More attention is needed for the sustainable use of locally and regionally available feed resources, and adaptation to and proper use of local circumstances and implementation of context specific practices. This could be combined with continuous system innovations, not only introducing new techniques, but also tuning existing and traditional practices.

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Exploration and design, and the role of science

Integrative systems-oriented approaches deal with the competing claims on resources that serve as inputs and the multiple commodities and positive and negative externalities that agricultural systems produce as outputs, using selected indicators. In combination with adaptive approaches in which policies and system interventions are seen as experiments that need to be continuously monitored, updated and adjusted, systems approaches provide an alternative to single technology based adjustments and linear extension models. To develop improved livestock feeding systems following these principles, we could structure projects in several phases, coinciding with the classical steps of the problem solving cycle. Scientific effort can lubricate this process by supporting exploration (quantifying impacts, generating and evaluating alternatives, and visualizing relations between indicators) followed by design (selection, fine-tuning and implementation) of a desirable future management option.

In projects aiming to improve livestock production systems, exploration serves to systematically create a large diversity of alternatives to choose from. This enables scientists and planners to make the synergies and trade-offs among the system indicators explicit. The aim is to inform farmers and to feed the discussions among farmers, stakeholders and policy makers by providing quantitative insight in the 'room to manoeuvre' and in the resource use configurations of possible alternative systems. In the design phase, a decision needs to be made about the most desirable alternative to be implemented and to be fine-tuned to the local conditions. Identification of the most desirable alternative may be informed by the visualization of trade-offs and the resource use configurations. However, conflicts between indicators are likely to exist and an acceptable compromise may be difficult to attain. In addition, the indicators that describe the system outputs are usually based on scientific approaches and may be technical and complex in nature. To translate the multitude of possibly conflicting science-based indicators to a set of indicators that describe more directly the demands of farmers, policy makers or society at large, indicators may be weighted based on multi-criteria decision techniques. In various projects involving exploration and design of novel systems, integrative goal-oriented modelling approaches have proven to be effective to support innovative farming system development (e.g., Groot *et al.*, 2007; Tittonell *et al.*, 2007).

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Use of different technologic to guarantee feeding animals in the tropic

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Introduction

Feeding is one of the most urgent problems in tropical livestock production and in spite of the advances that allow utilization of local resources, due to poor knowledge transfer and lack of training for producers, they are not applied, and thus difficulties still remain to be solved.

Silages

The low nutritive value of grasses, the high moisture levels of some agro industrial residues, the poor crude protein contents of sugarcane and rice straw and the prevailing view that specialized machinery is necessary for the preparation of silages, have limited their use. With mixed silages of grasses and legumes, in ratios 70:30 a well-preserved feedstuff is obtainable with crude protein levels above 12% giving a 10% increase in food intake (Ojeda *et al.*, 2008b).

In four studies of silage making using wet byproducts, like citrus and pineapples pulp, the inclusion of between 10 and 15% of an absorbing material like grass hay, bean straw or sugarcane bagase, permits increases in total dry matter of more than 30% which allows better fermentative quality and avoids the loss of soluble compounds. There is an increase of nitrogen compounds with urea up to 4% but this feed is acceptable if 3% lactic strains are introduced (Ojeda *et al.*, 2008a).

This kind of citrus silage used over a five year period under production conditions and supplemented with an integral diet for bull fattening with forage, hay and commercial concentrate can achieve average, live gains of 0.633 Kg/Animal/Day (Ojeda *et al.*, 2010)

Ammonization of sugar cane or bean straw with urea, up to 4%, transforms this by products normally high in dry matter (over 50%) and low in crude protein (under 3%) into a much improved feedstuff with nutritive values above 30%. These procedures require chopping the materials until 2 cm with a stationary chopper.

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