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Intake pattern and nutrient supply of lactating sheep selecting dried forage from woody plants and straw offered in binary or multiple choice

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ABSTRACT

This study investigated whether offering either binary or multiple choice among low quality forages has an effect on intake and feeding behaviour compared to no-choice situations where only one single low-quality forage is offered. Forages from different woody plants and straw were tested in lactating sheep either in Syria (Exp. 1; Awassi sheep) or in Switzerland (Exp. 2; East Friesian Dairy sheep). *Artemisia herba-alba*, *Atriplex leucoclada*, *Haloxylon articulatum*, *Noaea mucronata*, and *Salsola vermiculata* were used in Exp. 1. The three most preferred plants (*A. leucoclada*, *H. articulatum* and *S. vermiculata*) were tested again in Exp. 2 together with *Betula pendula*, *Castanea sativa* and *Juglans regia*. Both experiments started with a binary choice test where one plant and barley straw were offered separately for 4 h in the morning to six sheep (test period) in a random sequence in consecutive 7-day subperiods. A control group ($n = 6$ per experiment) received only straw in the test period. For the rest of the day, a basal diet composed of straw *ad libitum* and concentrate was offered. After the binary choice test, two 2-week periods followed, where in the first straw only and in the second all test plants were offered to all animals from both groups to ascertain equal familiarisation with all plants. For the following 7-day multiple choice test animals were allocated to two new groups. The 'multiple choice' group could choose among all test plants and straw during the 4-h test period, the 'control' group received only the basal diet. Intakes of test feeds during 4 h and 24 h as well as feeding behaviour during the first 30 min were recorded. Additionally, nutrient intake was determined. Total daily test feed intake was always higher in the choice groups, but this was more pronounced in the multiple choice situation (Exp. 1: 30 and 48, Exp. 2: 49 and 74 g dry matter/kg live-weight$^{0.75}$ with 'control' and 'multiple choice', respectively). *A. leucoclada* (Exp. 1; proportionately 0.73 of total test plant intake) and *B. pendula* (Exp. 2; 0.87) were the preferred plants in the multiple choice test and also with binary choice. Most other feeds were only consumed in low amounts in the binary and even less in multiple choice situations. In conclusion, giving sheep the choice among low quality forages seemed to be advantageous. Even though in both experiments animals preferred especially one plant, choice still facilitated intake.

Abbreviations: ADFom, ash-free acid detergent fibre; aNDFom, ash-free neutral detergent fibre; CP, crude protein; CT, condensed tannins; DM, dry matter; EE, ether extract; Exp., experiment; lignin(sa), lignin determined by solubilisation of cellulose with sulphuric acid; non-fibre CHO, non-aNDFom carbohydrates; OM, organic matter; TP, total phenols; TT, total tannins.

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1. Introduction

In the Mediterranean area, livelihood of nomadic and semi-nomadic people is based on rangelands which are the major feed source for their animals (Louhaichi and Tastad, 2010). However, dry and semi-arid areas are affected by climate change manifested with more pronounced droughts and more irregular precipitation events (Hadri and Guellouz, 2011) which together with overgrazing facilitate degradation of the rangelands (Louhaichi and Tastad, 2010). The latter group of authors stated that, therefore, farmers are shifting to systems consisting of a combination of free-range grazing and supplementary feeding and local governments initiated re-cultivation programmes with woody plants to stop and reverse degradation of the rangelands. The use of woody plants as supplements during the dry season might become increasingly important. In arid areas several woody plants are used as potentially high quality supplements to the available low protein forage (Leng, 1997). However, only few woody plant species were evaluated for their acceptability by sheep. The feeding value of woody plants might be impaired as they may contain substantial levels of potentially harmful compounds. An increasing plant species diversity of the diet gives the animals the opportunity to compose their own mixed diet (Duncan et al., 2003). This enables the animal to consume more plants either complementary in nutrient composition, or with potentially harmful compounds (Lyman et al., 2008) by benefitting from the biochemical complementarity of these compounds (Manteca et al., 2008). Generally, a more diverse feed offer could increase intake (Rogosic et al., 2008) by increasing the animals' motivation to eat (Ginane et al., 2002) and improve performance by giving the animals the chance to select a nutritionally optimised diet (Duncan et al., 2003).

The hypotheses tested in the present study were that (i) offering different low quality forages in a binary or a multiple choice situation leads to a higher total intake during the choice feeding period and across the entire day, and (ii) a choice feeding situation improves nutrient intake compared to no-choice situations. Differences in preference pattern were expected with regard to the different woody plants on offer; however, no difference in preference pattern between the binary and the multiple choice situation was anticipated. For this purpose, two experiments were conducted in different climatic regions with two local dairy sheep breeds testing various woody forages and straw.

2. Materials and methods

2.1. Study regions

The sites selected were located in the Mediterranean region, having a warm and dry climate, and in central Europe, with a temperate and more humid climate. The Mediterranean experiment (Exp. 1) was conducted at the International Center for Agricultural Research in the Dry Areas (ICARDA, sheep barn: 36.0245 N, 36.9545 E, 296 m a.s.l.), Aleppo, Syria, from April to July 2010 (spring and summer). The central European experiment (Exp. 2) was conducted at the Institute of Animal Nutrition of the University of Zurich, Zurich, Switzerland (sheep barn: 47.3946 N, 8.5507 E, 518 m a.s.l.), from June to September 2011 (summer). The procedures followed in Exp. 2 were approved by the Cantonal Veterinary Office of Zurich. Exp. 1 was identical in terms of animal handling; however, in Syria no approval procedures were established by the government. The design of the two experiments was in agreement with the "International Guiding Principles for Biomedical Research Involving Animals" issued by the Council for International Organizations of Medical Sciences.

2.2. Test feeds and basal diet

For Exp. 1, leaves with twigs of five different sprouting steppe shrub species (*Artemisia herba-alba*, *Atriplex leucoclada*, *Haloxylon articulatum*, *Noaea mucronata*, and *Salsola vermiculata*) were collected in the Syrian steppe in March and April 2010. The plant material was air-dried in the shade for several days before it was offered as test plants to the sheep. For Exp. 2, dried material from the three best eaten shrubs from Exp. 1 (*A. leucoclada*, *H. articulatum*, and *S. vermiculata*) was chopped to a maximal size of the twigs and leaves of about 3 and 1 cm, respectively, and then transported to Switzerland. Additionally, leaves of the tree species *Betula pendula*, *Castanea sativa* and *Juglans regia* were purchased from Alfred Galke GmbH (Gilltelde, Germany). These leaves had been harvested in Albania (*B. pendula*, *C. sativa*) and in Bulgaria (*J. regia*), dried in the shade and chopped to a maximum size of 1 cm before selling. In both experiments local chopped barley straw was used as low quality control forage.

The basal diet which was offered daily during the entire experiments to meet the animals' requirements for maintenance and lactation consisted of barley straw *ad libitum* and concentrate (1070 and, on average, 782 g/day per animal in Exp. 1 and 2, respectively). In Exp. 1 the concentrate was mixed (g/kg) using whole barley grains (882), soybean meal (98), dicalcium phosphate (12), sodium chloride (6), and vitamin–mineral premix (2). The latter provided per kg of concentrate: Ca, 270 mg; Na, 243 mg; P, 212 mg; Mn, 1.52 mg; Mg, 0.30 mg; Co, 0.23 mg; I, 0.15 mg; vitamin A, 24,500 IU; vitamin D_3, 600 IU; vitamin E, 1 mg. In Exp. 2, a concentrate designated for dairy sheep and goats (Combifloc 2957C) was purchased from a commercial producer (Melior AG, Herzogenbuchsee, Switzerland). It consisted of wheat, barley, wheat starch, wheat and maize flakes, various mill by-products, distiller's grains, soybean meal, maize gluten, canola expeller, sugar beet pulp, molasses, and vegetable oil. It also included a mineral-vitamin premix in an amount providing, per kg of concentrate, Ca, 11 g; P, 5.5 g; Mg, 3 g; vitamin A, 25,000 IU; vitamin D_3, 5000 IU, vitamin E, 25 mg. Additionally the sheep of Exp. 2 were given continuous