ABSTRACT

For many years energy needs of ruminants have tried to be known to formulate rations adjusted, but it has been found that there are a variety of factors that affect them. Therefore, lots of studies are needed for evaluating the effect of these factors.

Consequently, the main objective of this Thesis was to design and validate a respirometry system based on indirect calorimetry, which would allow assessing energy needs of small ruminants accurately. It was intended from the beginning it was a mobile system and of relatively low cost. Furthermore, a methane gas analyzer was incorporated to this system, which allowed the measurement of emissions of this greenhouse gas and quantification of energy losses in the form of methane.

Initially the system had connected a mask, which was placed on the animal's face. A sample of exhaled gas was stored in a gas collection bag which was connected to the analyzer, and it measured the concentration of O_2, CO_2 and CH_4 from the air. The proper functioning of the system was checked by a pilot experiment with dry Murciano-Granadina breed goats fed at maintenance level. Later this system was improved. Some of the most important changes were the replacement of the mask by a head hood in which the animal introduced the whole head, and the development of software that recorded and kept automatically concentrations of O_2, CO_2 and CH_4 in exhaled air. This improvement allowed gas measurements during longer periods of time and recording more data. These changes were also validated through a pilot test with dry Manchega breed sheep.

Subsequently, three experiments were performed. Diets were mixed rations that differed in the inclusion of cereal or fibrous by-products. The effect of diet was studied on digestibility, energy and carbon-nitrogen balances, nutrients oxidation, rumen parameters, methane production and, where appropriate, on milk performance. Dry Guirra ewes were used in the first experiment and it was found that replacement of cereal by fibrous by-products had no negative effect on energy metabolism and resulted in positive energy balance (62 kJ/kg $BW^{0.75}$, on average). In the other two experiments Murciano-Granadina goats during mid lactation were used. In the first one, the diet not affected the energy balance, which was positive, with an average value of metabolizable energy intake of 1,444 kJ/kg $BW^{0.75}$. In the next experiment goats showed negative energy balance, that was accentuated with the replacement of cereal by fibrous by-products. The most unfavorable case was the fibrous diet which presented a fat oxidation of 74.4% compared to carbohydrate oxidation of 18.5%. Methane production was also higher for fibrous diets (34.8 g/d, on average) than for cereal diet (24.7 g/d). In both studies with lactating goats no effect of the diet on milk yield was observed; however, the fat content of milk increased, like acetic acid production in the rumen.

The determination of the calibration factor for O_2 (1.005 ± 0.0101) confirmed the proper functioning of equipment. Moreover, small differences between the heat production obtained by indirect calorimetry and the carbon-nitrogen balance (2% in sheep and 1% in goats) demonstrated that this system allows determining the heat production of the animals reliably and accurately.

In the experiments of this Thesis have been estimated maintenance energy needs of two Spanish native sheep breeds, such as the sheep from the Guirra and Manchega breeds, by lineal regression or measurement of fasting heat production, respectively; net maintenance requirements were 270 kJ/kg $BW^{0.75}$, on average. In the case of Murciano-Granadina breed goats, in the middle of lactation, the average utilization efficiency of metabolizable energy for lactation was 0.61.