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The effect of milk source on body weight and immune status of lambs

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ABSTRACT

Milk source is one of the several factors that can affect lamb body weight (BW) and immune status before weaning. The aim of this experiment was to evaluate the effect of milk source (natural rearing method, named NR group, vs. artificial rearing method using a commercial milk replacer, named MR group vs. artificial rearing method using whole powdered cow milk, named CM group) on the BW and immune status of lambs during the milk feeding and weaning period. In this study, 60 lambs were equally divided according to sex and then randomly divided in three groups (NR, MR and CM). Blood plasma was collected to measure the immunoglobulin concentration (IgG and IgM), the chitotriosidase activity and complement system activity, total complement activity (TCA) and alternative complement activity (ACA). Results showed that lambs reared with NR presented, in general, higher BW, IgG, IgM, TCA and ACA than animals reared with MR or CM at 3 and 5 days after birth ($P < 0.05$). These differences, however, disappeared during weaning. At the end of weaning, animals from MR and CM groups showed higher BW than NR lambs (15.28, 16.89 and 17.66 kg in NR, MR and CM groups, respectively, $P < 0.05$). In addition, MR and CM groups showed higher IgM concentrations than the NR group (1.05, 1.90 and 1.60 mg/mL in NR, MR and CM, respectively, $P < 0.05$). Present findings may improve the management in sheep farms, reducing the expenses of the artificial rearing systems if the described alternative milk feeding source (whole powdered cow milk for human consumption) is selected for feeding lambs reared under an artificial rearing system. Accordingly, these results can be used for increasing the economic benefits of the sheep producers.

1. Introduction

Newborn ruminants have three critical periods affecting their immune system during the first months of life: colostrum intake, milk feeding and weaning and the management

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during these periods affects the final animal performance (Marsico et al., 1993; Massimini et al., 2007; Mastellone et al., 2011).

The milk feeding period is an important stage in newborn lambs because milk is the only energy source for these animals. Nowadays, there is an increasing number of high production dairy farms, in which artificial rearing is chosen in order to increase the amount of sheep milk available for processing (Demiroren et al., 1995; Napolitano et al., 2008) and simplifying management (Emsen et al., 2004). In this system, lambs are separated from dams at early age (0–2 days) and are subsequently fed with a milk replacer. It has been recommended to feed lambs with milk replacers that have been specifically formulated (Frederiksen, 1980), which are based mainly on cow's milk, cereals and vegetable fats (Banon et al., 2006). Nevertheless, milk replacers for lambs are usually considerably more expensive than high quality calf milk replacer or in some regions, whole powdered cow milk for human consumption.

Weaning is a critical phase in domestic ruminant production, mainly because any change produced by feeding strategies (frequency and composition) can be perceived as a stressor in preweaning ruminants (Hernández-Castellano et al., 2013a; Hernández-Castellano et al., 2013b). These stressors increase susceptibility to a variety of infectious diseases in ruminants as a consequence of the attenuation of the immune system (Sowinska et al., 2001; Hickery, 2003). For this reason, there is an increasing interest in finding effective dietary stress reducers and immune enhancers that may improve disease resistance in weaning ruminants (Kwon et al., 2011; Lerias et al., 2013).

The immunoglobulin plasma concentration (mainly IgG and IgM) is likely the most important and most studied humoral immune parameter (Klobasa and Werhahn, 1989; Mukkur et al., 1998; Hashemi et al., 2008), playing a crucial role in the host defense against external agents. In addition, there are other immune components, such as the chitotriosidase (ChT) activity and the complement system activity, that play a fundamental role in the innate immune response, acting as a part of the host defense in newborn ruminants. Chitotriosidase is predominantly a secretory protein that is able to hydrolyze chitin in the cell wall of fungi and nematodes (Barone et al., 1999). This enzyme is a functional chitinase with high homology to chitinases that belong to family of 18 glycosyl hydrolases. Chitotriosidase activity has been strongly related to the host defense (van Eijk et al., 2005). In fact, this enzyme has been investigated in humans (Musumeci et al., 2005) and goats (Argüello et al., 2008; Hernández-Castellano et al., 2011; Moreno-Indias et al., 2012c). Despite the recent publication of the ChT activity in artificially reared newborn lambs (Hernández-Castellano et al., 2015b), this study described that values only are available during 20 days after birth.

The complement system activity (Total (TCA) and alternative (ACA) pathways) is involved in specific and nonspecific immunity, playing an important role in defense mechanisms against infectious microorganisms (Rodriguez et al., 2009). The complement system has been well described, particularly in humans and mice, but it has also been examined in ruminants, such as cows (Mayilyan et al., 2008) and goats (Moreno-Indias et al., 2012a; Moreno-Indias et al., 2012c). However, there are few studies about the complement system activity in sheep and lambs (Oswald et al., 1990).

The aim of the present study was to analyze the effect of milk source (natural rearing vs. artificial rearing fed with commercial milk replacer vs. artificial rearing fed with whole powdered cow milk) on the BW evolution, the blood plasma IgG and IgM concentration, as well as the ChT and complement system activity during milk feeding and the weaning period.

2. Materials and methods

The present study was performed at the Department of Animal Science of the Universidad de Las Palmas de Gran Canaria in Canary Islands (Spain) on 60 lambs (30 males and 30 females) of Canarian breed. This breed is a high yield dairy breed (1.8 L/d) with a lactation period of 180–200 days (Trujillo-Álvarez, 2010; Hernández-Castellano et al., 2014). All experimental animals were born at a similar time ($\pm$ 2 d). Animal health status was monitored during the experimental period (for diarrhea, parasites or fever) and all animals were healthy throughout the experimental period. Animal procedures were approved by the Animal Welfare Ethical Committee of the University.

2.1. Colostrum period

During the first 2 h after birth, lambs were dried, weighed, ear tagged and injected with vitamin AD3E according to Loste et al. (2008). Thereafter, animals were equally divided according to sex and then randomly divided in three different groups by diet. The natural rearing group (NR) was composed of 20 lambs (10 males and 10 females) that received colostrum directly from their dams. The milk replacer group (MR; 10 males and 10 females) and whole powdered cow milk group (CM; 10 males and 10 females) were artificially reared without dam contact. Both artificially reared groups (MR and CM) were bottle-fed with a pool of pasteurized sheep colostrum (37 °C). The colostrum pasteurization was performed at 63 °C for 30 min according to Trujillo et al. (2007). Based on the study published by Hernández-Castellano et al. (2015a), lambs received a total colostrum amount equivalent to 4 g of IgG/kg of BW during the colostrum period (0–2 d after birth). Sheep colostrum IgG concentration was determined using a commercial ELISA kit (Bethyl laboratories, Montgomery, TX, USA), using purified sheep IgG (Bethyl laboratories, Montgomery, TX, USA) as the reference standard.

2.2. Milk feeding period

The NR group was raised with free access to their dams until the weaning period and ewes were not milked during this period. After the colostrum period, the other 40 lambs were randomly assigned to two artificial rearing groups. One group (MR group) received a commercial milk replacer (95.5% DM, 23.6% CP and 22.7% ether extract, air-dry powder basis; Bacilactol Corderos y Cabritos, Saprogal, La Coruña, Spain) at 16% (w/w) as described by Hernández-Castellano et al. (2015b). Further details about the milk