Methods of feeding colostrum and their effect on the passive immunity

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Abstract

Passive transport of colostral immunoglobulins is essential for calves to maintain optimal health. There are many factors that influence the absorption of immunoglobulins such as colostrum density, timing of ingestion, volume of colostrum but also the method of feeding. This study compares two manners of feeding calves – the esophageal tube feeder (n = 97) and the nipple bottle (n = 97), and their effect on the number of all absorbed immunoglobulins (IgG, IgM, IgA, IgD, and IgE). It was statistically proven that absorption of immunoglobulins is better with the nipple bottle ($P < 0.0001$). The feeding of calves through a nipple bottle is more beneficial because the content of total protein is the higher than by the feeding through an esophageal tube feeder.

Calves, total protein, nipple bottle, esophageal tube feeder

Calf morbidity and mortality is associated with high costs for the farmer, such as compensation for calf losses or the costs of medical treatments (Mohd et al. 2012). Moreover, calf morbidity and mortality are important animal welfare issues (Mee 2013).

Immunity is the ability of the body to resist the pathogenic invasion. Insufficient immunity threatens the health and overall survival and so its maintenance and improvement are of primary importance (Patel et al. 2015). Appropriate development of the innate immune system is essential so that newborn calves would survive, especially when they face the pressure of infectious diseases that are responsible for high morbidity and mortality. In the first several months of life, newborn calves have a weakened immune system because the function of granulocytes and their complete activity are low (Cervenak and Kacskovics 2009; Cortese 2009) and the specific immunity of calves has not developed sufficiently yet (Boysen et al. 2006).

The placenta of the cow separates the maternal and foetal blood supplies, preventing *in utero* transmission of protective immunoglobulins (Ig) (Arthur 1996). Consequently, the calf is born nearly agammaglobulinaemic, depending almost entirely on the absorption of maternal Ig from the colostrum after birth. The absorption of maternal Ig across the small intestine during the first 24 h after birth, termed passive transfer, helps to protect the calf against common disease organisms until its own immature immune system becomes functional (National Animal Health Monitoring system 1996; Weaver et al. 2008).

Factors influencing the optimization of colostrum include the timing of colostrum ingestion, the method and volume of colostrum administration, the immunoglobulin concentration of the colostrum ingested, and the age of the dam (Weaver et al. 2008). Successful passive transfer is important to dairy producers for several reasons. Failure of passive transfer (FPT) has been linked with increased calf morbidity and mortality and a reduction in calf growth rate (Robison et al. 1988; Wells et al. 1996; Donovan et al. 1998). In addition, FPT in heifer calves affects long-term productivity - low IgG levels

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have been associated with decreased first- and second-lactation milk production and an increased culling rate during the first lactation (DeNise et al. 1989; Faber et al. 2005).

Milk intake is a very short but very important life manifestation. The duration of the feeding time and the time interval between the individual phases depends mainly on the way of milk administration and also on the calf's sex and individuality. The most physiological way of feeding is sucking milk from the mother, where the time is relatively long and the time span depends on the time required to digest milk after which the calf starts to feel hungry. The disadvantage is that the amount of drunk milk cannot be controlled. Feeding calves with a nipple is the most common and most effective way, either with a nipple attached to a bottle or a bucket, or a separate nipple inserted into a milk drink. Colostrum, or milk, reaches its destination, i.e. the fourth stomach (abomasum), in the most natural way. The swallowing reflex then works optimally. This method is also suitable for the administration of acidified milk during the entire period of milk nutrition (Strapák et al. 2013).

The esophageal feeder is a long, narrow, rigid tube which is inserted in the esophagus of the newborn calf. A bottle or bag on the other end of the tube contains the fluid which is then released to flow into the calf's stomach. The use of the esophageal tube provides a quick and simple method of ensuring delivery of Ig to newborn calves (Arthington 2001). The use of the esophageal feeder to feed large quantities of colostrum has been associated with lower apparent efficiency of IgG absorption (AEA) and slightly lower serum IgG concentration compared to feeding colostrum by a nipple bottle (Lee et al. 1983). When colostrum is administered by the esophageal feeder, the colostrum enters the rumen before moving into the abomasum and intestine (Lateur-Rowet and Breukink 1983). It takes 2–4 h for the colostrum to leave the rumen. This may actually be the reason for lower AEA, as the intestine matures during this time, reducing the number of actively absorbing cells in the intestine. However, many veterinarians recommend feeding four quarts of colostrum as soon as possible after birth, to ensure that all four quarts are consumed (Quigley 1997). Others (Molla 1978; Adams et al. 1985) support the use of esophageal feeders to provide large amounts of colostrum without a significant effect on serum IgG concentrations.

The use of an esophageal feeder is most beneficial when the colostrum quality cannot be determined. When it is impossible to determine with great precision the quality of colostrum, there is a risk that an insufficient amount of Ig will be provided to the calf in the first feeding. Additionally, the efficiency of Ig absorption declines as the calf ages, so the first feeding may be the most important. Therefore, it has been recommended to use a large first feeding (1 gallon) without being concerned about sufficient consumption at the second feeding 12 h later (Quigley 1997).

The aim of this study was to find out which of these methods (esophageal feeder or nipple bottle) is best suited for feeding calves and for better absorption of immunoglobulins.

Materials and Methods

The experiment was carried out on a dairy farm in Petrovice, Czech Republic, owned by the farm of Krásná Hora nad Vltavou. The experiment was conducted using 194 Holstein calves (109 bulls and 85 heifers) divided into two groups. Calves in the first group (n = 97) were fed through the esophageal tube feeder; the second group of calves (n = 97) were fed with a nipple bottle. Both of these groups were given colostrum of the same density. All calves were housed in the stable for calves after the birth in individual boxes without enclosures. These boxes are bedded with straw. Immediately after milking, each colostrum was checked with a hydrometer and the values were recorded. The feeding of the calves was carried out within 2 h after the birth at an amount of 3 l. Around day 3–5 of their age, blood was taken from the jugular vein for the control of total proteins. This method was the same as the method of Jagoš and Bouda (1980) who recommended determining immunoglobulins between days 2 to 7 of the calf's age. The blood was centrifuged and, the value of serum proteins in particular calves was determined using a refractometer (PEN-PRO, Atago, USA) and recorded. The sex, time of birth, time of feeding, density of administered colostrum and the found value of blood total protein were recorded for each calf. All procedures were approved by the Specialized Committee for Ensuring the Welfare of Experimental Animals of the University of the South Bohemia in České Budějovice.

To evaluate the effect of milk density, sex and use of tube feeders and their interactions on the number of immunoglobulins (log-transformed data), a linear model with a normal distribution was used. At first, all the explanatory variables were used in the model, and then, the model was simplified (backward selection) by the stepAIC function to the resulting model best describing the collected data. Data were analysed in the program R version 3.1.2 (Core Team R 2013); for visualization of graphs, the library Ggplot2 (Wickham 2009) was used; and to visualize the results of the final model we used the library effects (Fox 2003).

Results

The impact of the density of colostrum administered to calves with an esophageal tube feeder and a nipple bottle was excluded as the first in this study. Calves received colostrum of the same density (1 040–1 070 g/l). Both experimental groups of calves were fed with 3 l of colostrum within 2 h after birth. No effect of sex on the number of total proteins was found, either.

The mean values of total protein were 5.65 g/dl in calves fed with a nipple bottle, and 5.18 g/dl in calves fed with a tube feeder (Table 1). The low values of total protein in the blood (> 5.2 g/dl) from all experimental calves were found by 12 calves fed through the esophageal tube feeder and 9 calves fed with a nipple bottle. The linear model was simplified in the resulting linear model (Fig. 1) best describing the obtained data, where the impact of the tube feeder application on the number of total proteins in milk ($F_{1.192} = 39.266$; $P < 0.001$) was proven.

Table 1. Number of calves and the mean values of total protein.

	Total calves	Bulls	Heifers
Number	194	109	85
Total protein - esophageal tube feeder	5.18[a] g/dl	5.14[a] g/dl	5.22[a] g/dl
Total protein - nipple bottle	5.65[b] g/dl	5.62[b] g/dl	5.7[b] g/dl

[a,b] - values with different superscripts within columns are significantly different ($P < 0.001$)

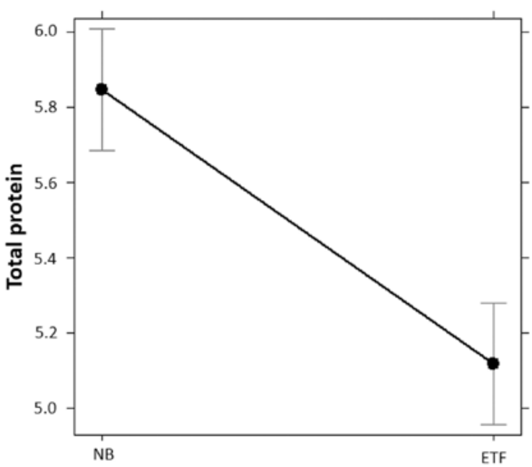

Fig. 1. The effect of the method of feeding – nipple bottle (NB) vs. esophageal tube feeder (ETF)

Discussion

The concentration of colostrum IgG is an important factor affecting whether calves receive sufficient passive immunity by colostrum (Godden et al. 2012). One way to measure the colostrum IgG content indirectly is by means of a colostrometry (50 g IgG/l = density 1 045 g/l) (Chigerwe et al. 2008). The effect of density was excluded because the experimental calves were fed by colostrum of the same density. Calves were fed with the colostrum within 2 h after birth, which is the most appropriate time according to Chigerwe et al. (2008) and Godden et al. (2009). A study by Sakai et al. (2012) claims that there is no additional benefit by administration of 4 l of colostrum compared to 3 l, if the colostrum is of comparable quality, and when using a nipple bottle, 2 l of colostrum is sufficient (Kaske et al. 2005). Receiving colostrum using a nipple bottle is physiologically more acceptable for calves since it represents a natural feed intake, salivation occurs and it is not necessary to feed the calf with an excessive amount of colostrum. Compared to nipple bottle, feeding with an esophageal feeding tube requires experience of caregivers to avoid irritation or even injury of the calf or the introduction of the tube into the trachea. This feeding method is faster but from a physiological point of view, even too fast and stressful, and often dangerous for the calf. Studies on this issue (Adams et al. 1985; Godden et al. 2009; Elizono-Salazar et al. 2011) indicate that the administration of colostrum using an esophageal feeding tube does not impair the absorption of immunoglobulin G. The contrary finding of our study may be due to the fact that the value of the immunoglobulins was determined on the basis of the amount the total protein (TP). Even though immunoglobulin G has the highest proportion of all immunoglobulins and is the most important for obtaining passive immunity, it is also important to take IgA and IgM into account. Weaver et al. (2008) concluded that measurement of the total protein content by a refractometer is suitable for monitoring the obtained passive immunity, and provides a reasonably accurate assessment of the passive transmission state. The authors state that a total protein concentration of > 5.2 g/dl indicates an adequate passive transmission. It is therefore evident that there was very good passive transfer (TP ø 5.65 g/dl) when using a nipple bottle versus using an esophageal feeding tube (ø TP 5.18 g/dl).

In conclusion, comparing the two methods of feeding, with the esophageal tube and the nipple bottle, and their effects on the total protein content in calves showed a significant difference ($P < 0.001$). The mean value in calves fed with a nipple bottle was 5.65 g/dl, and in calves fed with an esophageal tube it was 5.18 g/dl. The results show that the feeding using the bottle is more natural to calves, as while being sucked gradually, colostrum is salivated. The use of an esophageal feeding tube is suitable especially for calves that have not developed their sucking reflex or have other health problems, on order to ensure their timely feeding and obtaining sufficient amounts of immunoglobulins that provide passive immunity. The sucking with a nipple bottle is more natural, safer for calves therefore, this method is more beneficial for practice.

Conflict of interest

The authors declare no conflict of interest.

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