COLOSTRAL IMMUNITY IN NEWBORN CALF: METHODS FOR IMPROVEMENT OF IMMUNOGLOBULINS ABSORPTION

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Summary

Rearing healthy calves with minimal mortality is crucial in a successful dairy farm. The period between calving and weaning is the most important period in the animal's life. Reducing health problems in calves can be achieved through colostrum. The importance of colostrum for the growth and health of newborn offspring is well known (14,30). Because newborn calves are agammaglobulinemic at birth they need good quality colostrum fed as soon as possible after birth, but when quality, quantity, quickness of providing the first colostrum feeding after birth, cleanliness of colostrum are affecting the mass of Ig consumed by the calf, appears the failure of passive transfer of immunity (31). That’s why we reviewed some methods for improvement the absorption of immunoglobulins.

Key words: calves, colostrum, immunoglobulin G

Abbreviation key: Ig = immunoglobulin, IgG = immunoglobulin G, CS= colostrum supplement.

Growing animals determine a continuous research of all possibilities which could improve health status and productivity. That’s why early human intervention after calving will influence the health and productive future of the calf. The newborn, how comes from a sterile medium, suddenly, after parturition, confronts a large variety of microorganisms potential pathogen.

Newborn is protected from external factors through passive immunity, of maternal origin. Maternal protection depends on placenta type: on mammals with hemochorial placenta (primates) it’s done before parturition, on those with endotheliocorial placenta (carnivores) the protection is mixed, through placenta and colostrum, and on those with sindesmochorial placenta (ruminants) and epitheliocorial placenta (equine and pigs) the protection is obtained entirely after parturition (1,16,21).

Because of sindesmochorial placenta, the calf is born agammaglobulinemic, immunoglobulins are taken from colostrum, in a limited period of time. Colostral period represents an important moment of passive transfer of immunity, and from that depends starting a good protection against neonatal diseases.

Cow colostrum composition

Colostrum is the secretion from the mammary gland in the first 24 hours after calving and is an important source of nutritional, growth and antimicrobial
factors for the newborn calf (31). The most important are immunoglobulins that provide passive immunity to the calf. Each millilitre of bovine colostrum contains 2-3·10^6 cells from the immunity system (21,30). Colostrum contains three types of immunoglobulins: IgG (subtype IgG₁ and IgG₂), IgM and IgA, where IgG₁ represents 80 % of the total as shown in table 1 (10,30,31). IgG₁ come from maternal blood, proven by the massive reduction of IgG₁ in maternal blood, for example on ewe starting with 2 weeks before parturition IgG₁ concentration diminish from 15 mg/ml at 6 mg/ml (16,21).

Table 1.

<table>
<thead>
<tr>
<th>Species</th>
<th>Immunoglobuline</th>
<th>Concentration (mg/mL⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sangvin serum</td>
<td>colostrum</td>
</tr>
<tr>
<td>Bovine</td>
<td>Total Ig G</td>
<td>25.0</td>
</tr>
<tr>
<td></td>
<td>IgG₁</td>
<td>14.0</td>
</tr>
<tr>
<td></td>
<td>IgG₂</td>
<td>11.0</td>
</tr>
<tr>
<td></td>
<td>IgA</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>IgM</td>
<td>3.1</td>
</tr>
<tr>
<td>Human</td>
<td>Total IgG</td>
<td>12.1</td>
</tr>
<tr>
<td></td>
<td>IgA</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>IgM</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Colostrum also contains nespecific antimicrobial factors such as: lysozyme, lactoferrin, lactoperoxidase (BRUNO-REITER, 1978). Bovine colostrum contains 200-500 mg lactoferrin in 100 ml and so antimicrobial properties are due to her ability of binding iron, deprive some bacteria, as Escherichia coli, of growing factors. In this way bacteria are inhibited (16,29).

Macromolecules absorption

Macromolecules absorption take place across intestinal epithelium cells in two different ways: specific receptor mediated transcytosis and nonspecific transcytosis. Specific transport of macromolecules take place through binding Ig to specific receptors FcRn of enterocytes, the complex formed is located in plasmatic membranes depresions, placed preferential to the based of microvillas. FcRn receptor attach to Fc region from the second and third constant domain of the two heavy chains of IgG. A particularity of this receptor is its possibility to bind Ig at 6 pH intestinal and than to release it at 7.4 pH sangvin. Nonselective transport is ensured by vesicular transport of macromolecules that adhere to the surface membrane or are transported in the fluid-phase compartment of the vesicles. The functional ability of the intestinal epithelium to take up macromolecules seems to be related to the presence of the apical tubular system and large supranuclear vacuoles (16,19,21).
Immunoglobulins absorption is time limited, enterocytes permeability is high after calving, but in 6 hours is reduced by 50% because intestinal cells are replaced with mature cells population that don’t allow macromolecules transfer (8,9) or because of lysozyme activity of enterocytes that grow progressively, determine enzymatic digestion of Ig (16).

Bovine Alliance on Management and Nutrition (1995) established that 10 mg/ml IgG in calves serum at 24-48 hours after birth should be the minimum level of IgG for achieve a good passive transfer (2,9,12,30).

Medium efficient absorption of IgG, calculated in gramms IgG blood/ 24 hour is between 20-35% (23).

Due to factors that affects the mass of Ig consumed and the absorption of molecules into circulation, many calves (41% of 2177 calves in a study made by Centre for Animal Health Monitoring in 1993) have failure of passive immunity, and finally neonatal morbidity and mortality. This factors are quality, quantity of colostrum, time of providing the first colostrum feeding after birth, bacterial contamination of colostrum, other factors are: lactation number, breed, season of calving, dry period length, maternity microclimate, hygiene, immunity status of dam, genetic selection for high milk production etc (5,6,12,15,18).

Colostrum of high quality has to have >50 g/L IgG concentration. In order to achieve successful passive transfer the calf should receive at least a minimum mass of 100 g IgG/dose. Quantity of colstrum depends on quality, but because quality of colstrum is not frequently know is recommended that calves be fed 10-12% of their body weight of colosstrum at the first feeding (31). MOORIN and col. (1997) have demonstrated that high quality and quantity colostrum (4L) administrated in the first 3 hour of age comparative with 2L of quality colstrum determined an increase of IgG serum at 48 hours (30,41 mg/ml comparative with 20,82 mg/ml) (18). Colostrum can include infectious agents as *Mycoplasma* spp., *Mycobacterium avium* subsp. *paratuberculosis*, fecal coliforms, *Salmonella* spp., bovine leukemia virus and bovine viral diarrhea virus. This pathogenic agents can cause diseases such as diarrhea or septicemia. Fresh colostrum fed to calves is recommended to contain less than 100,000 colony forming units/ml (7,31). Because the ability of the calf to absorb large Ig molecules is time limited, term "open gut", the calves should receive as soon as possible colostrum within 1-2 hours after parturition. The quality of colostrum could be tested faster with colostrometer, an instrument that estimates colostrum quality by measuring specific gravity. MOORIN and col. (2001) found that high colostral specific gravity are in autumn-october, low in spring, is high in Holstein and Jersey breeds, and cows at third lactation. Low values had Brown Swiss and Ayrshire breeds, cow on first and second calving, and those who calved in summer (17). Other indicator of IgG concentration is total seric proteins. WHEELER and col. (2000) cit. by QUIGLEY and col. (2002) suggested that a concentration of total seric proteins higher then 5,2 g/dl indicates an adequate passive transfer (23).
Methods for improvement the quantity of immunoglobulins on calves

Because failure of passive transfer in calves is quite frequent due to lack of high quality colostrum or because it's contaminated with different pathogen agents or other causes, for the improvement of the immunoglobulins absorption it can be used colostrum supplement, colostrum replacers, or different natural substances added to colostrum. Colostrum supplement are products that contains <100g IgG/dose, and colostrum replacers contains >100g IgG/dose (29). Immunoglobulins from colostrum supplement result from lacteal secretion (milk or colostrum), bovine serum extracts or eggs (23,24). Immunoglobulins sources and methods of processing can influence absorption. For example, the use of polyethylene glycol for purifying IgG from plasma, lacteal secretion and eggs, reduced plasma IgG concentration by altered absorption kinetics, and addition of animal fat has no effect on absorption (24). Colostrum supplement obtained through spray dried method has a weak effect on diarrhea comparative with colostrum obtained by lyophilisation, perhaps due to immunoglobulins degradation through spray dried method (5). Most CS provide 25-45g IgG/dose, reconstituted in 2 L of water, therefore one or two doses of CS do not provide adequate mass of IgG. But CS efficiency depends on quality of colostrum in which is added, quantity and time of administration. Simply increasing the mass of powder offered does not improve the attainment of passive immunity (2).

Other alternative sources like: injectable Ig solutions (QUIGLEY and col., 1996 cit. by DEZFOULI and col., 2007)(5), dried colostrum (18), concentrated milk whey (MEE and col., 1996 cit. by DEZFOULI and col., 2007)(5) do not provide adequate passive immune support. Because CS have poor results on Ig absorption, vital for calf, researchers found other methods more efficient.

Natural and synthetic zeolites have been used in animal nutrition, since mid 1960’s, mainly to improve performance. Since 1980’s researches had demonstrated that their use additionally has favorable effects on the prevention and/or treatment of certain farm animal diseases. Zeolites are porous materials, characterized by the ability to lose and gain water reversibly, to adsorb molecules of appropriate cross-sectional diameter and to exchange their constituent cations without major change in their structure. Zeolites have a ameliorative effect on the consequences of mycotoxicoses, for example clinoptilolite has high adsorption indexes in vitro, more than 80%, for aflatoxins B₁ and G₂ (20). On high producing dairy cows zeolite A is used for the prevention of milk fever (20,27,28); also zeolites are used for the prevention of heavy metal toxicity in animals, in elimination of gas pollutants in confinement facilities (20), against zearalene toxicosis in pigs (26) and lambs (4). In calves clinoptilolite added in colostrum increased the net absorption with 40% (3,8,9,20). Administration of zeolites appeares to reduce the incidence of diarrhea through the enhancement of passive immunity, this is a result of:

-alteration of metabolic acidosis through effects on osmotic pressure in the intestinal lumen;
- adsorb and partially inactivate the thermo-labile *Escherichia coli* thus constricting its attachment to the intestinal cell-membrane receptors;
- adsorption >94% for bovine rotavirus and coronavirus (CLARK, K.J. and col., 1998 cit. by PAPAIOANNOU and col., 2005)(20);

Another product that improves Ig absorption in newborn animals is Bio-Mos, a product that contains phosphorylated mannan oligosaccharides extracted from cell walls of *Saccharomyces cerevisiae* yeast. Bio-Mos provinde competitive binding sites for the intestinal pathogens (11).

PORTO and col. (2007) demonstrated that jacalin, a lectin from seeds of fruit *Artocarpus integrifolia*, has the property to bind O-linked oligosaccharides, to obtain a colostral Ig population protected against enzymatic cleavage by the presence of sugar chains, enhancing 3-6 time more the IgG resistance to peptic hydrolysis. The authors think that this product used in calves feed will favor antibody absorption (22).

KAMADA and col. (2007) obtained in their research a rise with 20% of IgG seric concentration on newborn calves at 24 hour of age when they used 1,0 ppm selenium (Se) in colostrum. At 3 ppm Se the IgG level was with 42% higher. The answer was fast, this indicates that the selenium effect on absorption is not nutritional but pharmacological, it seems that Se works direct on intestinal level, activating pinocitosis (13). REFFETT and col. (1987) found that antibodies titre against *Bovine herpesvirus* were higher on calves that recieved selenium (0,2 mg/kg food). This results indicates that, selenium deficiences in calves cause decrease immunitary answer on action of pathogen factor (25).

**Conclusions**

The transfer of immunity from dam to newborn on bovine species, is made only through colostrum. This process is conditioned by the time between parturition and first administration of colostrum and also by the quality of colostrum, regarding IgG concentration from colostrum. Also, there are some ways for improvement the quantity of immunoglobulins absorption from colostrum: natural zeolite, clinoptilolite and products obtained from cell walls of *Saccharomyces cerevisiae* yeast. Selenium has also a positive effect, not only to prevent enzootic muscular dystrophy (white muscle disease) but can be used to rise immunoglobulins absorption.
References


