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Review

Colostrum: Mother nature's gift to the newborn animals

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Abstract

The first milk secreted by mammals is nearly equivalent to blood in nutritive value. In most of the mammals except humans no antibodies are transferred through placenta to the foetus. In all the species of animals, transfer of passive immunity depends on the quality and quantity of colostrum, which, intern depends upon the body condition of the dam before parturition, length of dry period, timing and method of colostrum feeding and vigour of the newborn. In case of unavailability of colostrum, cow colostrum can be used in all the species. In sheep and goat, more volume should be fed if using cow's colostrum. Cow colostrum can be preserved in small self-seal pouches in freezer upto one year. Biosecurity is very important while using colostrum from other farms. The presence of maternal antibodies may interfere in the effectiveness of vaccine in all the species of animals.

Key words: colostrum, immunoglobulins, immunity and antibodies.

Introduction

Colostrum is referred to as the 'first milk' produced by mammalian milk glands on the birth of a newborn, but this is actually much more similar to blood than milk (Butler, 1974). With vaccination and natural exposure to various pathogens, the cows develop many antibodies and strong immunities. During the last part of the pregnancy the cow puts these antibodies into the colostrum, so that the calf can have some instant immunity immediately after first nursing. These antibodies of colostrum are very important to the newborn because it has very little disease resistance of its own. The foetus can begin to produce antibodies against certain pathogens at various stages of development e.g. a foetus can start making antibodies against bovine viral diarrhoea and infectious bovine rhinotracheitis as early as 90 days after gestation and against leptospirosis after 180 days (Thomas, 2002). Some of these microbes can pass through the placental barrier from the mother's bloodstream if she becomes infected. That is how a feotus can become infected with BVD or other diseases and dies or get aborted. Certain infections in the cow can kill the foetus or cause it to born diseased, or cause it to start making some antibodies of its own. But this foetal immunity is not sufficient for the calf. This immunity of calf decreases at the time of birth, as a result of hindrance of its immune system by the high cortisol levels (which stimulates parturition) present in both the cow and calf. Antibodies in the cow's bloodstream are unable to cross the placental barrier because these molecules are large in

size. So, a calf can receive the antibodies from its dam only through consuming her colostrum.

Three major types of immunoglobulins i.e. IgG, IgM and IgA found in colostrum of dairy cows are 85-90%, 5-10% and 5-10%, respectively (Lang, 2008). Besides being very high in immunoglobulins for prevention of diseases and infection, the colostrum is a source of energy, vitamins, minerals, white blood cells and growth factors. Nutrients in colostrum such as fat and protein are also important to the newborn for growth and development. The lactose concentration in colostrum is less than is present in whole milk, which reduces the chance of diarrhea in newborn calf (Foley and Otterby, 1978).

Bovine colostrum is biologically transferable to all mammals including humans (Rona, 1998). It could be used as a health food supplement, which prevents non steroidal anti-inflammatory drug (NSAID) induced gut damage (Playford *et al.*, 1999).

Colostrum feeding and passive immunity

Inadequate passive immunity is the main reason of newborn calves getting sick in first few weeks of life. This is because of insufficient amount of antibodies absorbed after birth. If the calves nurse promptly, this problem can be greatly reduced. Resistance to diseases is greatly dependant on antibodies or immunoglobulins present in colostrum. The goal of proper colostrum feeding is to achieve a minimum blood serum IgG level greater than 10 mg/ml in a calf. As an alternative to testing IgG levels, serum total proteins can be measured. A serum total protein level of 5.2g/dl is considered equivalent to serum IgG of 10mg/ml (Zsuzsanna *et al.*, 1998) in cattle. The incidence of calf mortality increases greatly when blood immunoglobulin level falls below this threshold level and this is termed as 'Failure of passive transfer (FPT).' To achieve adequate serum levels of IgG, a general 'thumb rule' is that a calf should consume 100 g of IgG. From the analysis of blood samples of 263 crossbred calves collected at 24 hours after calving, it was concluded by Selk (2006), that the calves with inadequate passive immunity had a 5 times greater risk of death prior to weaning, 6 times greater risk of being sick during the first 28 days of life, and 3 times greater risk of being sick any time prior to weaning when compared to calves with adequate passive transfer. The passive immune status was indirectly associated with growth rates through its effects on calf health.

Absorption of antibodies

Out of IgG, IgM and IgA, IgG is the smallest immunoglobulin and is present in the greatest concentration. It can move from blood into the tissues where it destroys invading pathogens. IgM is a larger molecule, which remains in blood where it protects against pathogens that may invade the body. It is considered as the first line of defense against septicemia. IgA attaches to the mucosal cell lining of intestine and provide protection. So feeding colostrum for the first three days of life will provide IgA to protect the intestine against pathogens. Antibodies in the transition milk, taken latter than 12 hours are also beneficial to the newborn even though the calf can no longer absorb them through the

intestinal lumen. The antibodies, which reach the blood and lymph, are absorbed by the process of pinocytosis (Follay and Otterby, 1978). This absorption mode works more efficiently immediately after birth when the gut lining of calf is the thinnest, enabling the large molecules to pass easily. The lining begins to thicken after birth and the rate of pinocytosis decreases with age. A calf gets maximum absorption if it nurses within the first 15 to 30 minutes after birth (Thomas, 2002). After the first meal, the speed of closure process increases. This provides protection against invading pathogens from the lumen once the calf is exposed to the external environment. That is why it is important to give full feeding of colostrum to calf as soon as possible after birth. After the gut closure, the calf can only get the benefit of those antibodies (IgA), which fight a few pathogens in the gut itself.

The antibodies in the blood (IgM) obtained via colostrum can help the calf in fighting off blood born infections caused by bacteria such as salmonella, pasturella and streptococcus, but they cannot directly prevent gut infections. High level of certain antibodies in the blood can help in reducing the severity of scours, whereas, the antibodies, which stay in the gut (IgA) after the intestinal wall closure, can attack any scour-causing pathogens present in the gut (Lang, 2008).

Factors affecting quality and quantity of colostrum and availability of antibodies to the calves

1. Although quality of colostrum can vary from cow to cow, it is important that the first colostrum a calf receives should contain sufficient quantity of immunoglobulins. The concentration of antibodies decrease rapidly with each milking as the transition from colostrum to milk production occurs. Usually the second milking has 65% as much immunoglobulins as the first milking. By the third milking the level falls to 40% of the first milking (Lang, 2008). Some differences in the composition between true colostrum, transitional milk and whole milk are as follows:

Table 1. Chemical composition of colostrum, transitional milk and whole milk from Holstein cows

Component	Milking number			
	1	2	3	4
	Colostrum	Transitional milk		Whole milk
Total solids (%)	23.9	17.9	14.1	12.5
Fat (%)	6.7	5.4	3.9	3.9
Protein (%)	14.0	8.4	5.1	3.1
Lactose (%)	2.7	3.9	4.4	4.9
Antibodies (%)	6.0	4.2	2.4	0.09
Minerals (%)	1.11	0.95	0.87	0.74
VitaminA (ug/Dl)	295	190	113	34

Source: Foley and Otterby (1978)

Colostrum contains 3 to 5 times more protein than normal milk. Most of this increase in protein content is because of accumulation of immunoglobulins, particularly IgG.

The quality of colostrum also depends upon the total bacterial counts. The calves should be offered colostrum with total bacterial counts <1,000,00 colony forming units (CFU)/ml and total coliform counts <10,000 CFU/ml (Lang, 2008). The sources of bacteria could be either from dirty udders or dirty collection container. Trotz-Williams *et al.* (2006) reported high levels of bacteria in 12% of colostrum samples. Similarly, in another study (NAHMS, 1993) in the U. S. average total plate counts of 16.1 million CFU/ml and the total *coliform* counts of 2.7 million CFU/ml was found in colostrum samples from 12 dairy farms. This suggested that the attention should be paid to the cleanliness of colostrum, otherwise it may become the first way (because colostrum is the first feed of a newborn) to potentially expose the calves to various types of pathogens. The udder, milking equipments and calf-feeding equipments should be cleaned before harvesting, storing and feeding.

There are several factors which influence the amount of imunoglobulins absorbed by a newborn. Some factors are directly related to the amount available by the mother. These factors include 1) genetic composition of the dam, 2) age of the dam, 3) nutritional status of the dam, and 4) previous exposure of the dam to various antigens/vaccines etc. Among the common dairy breeds, Holstein has the lowest and jersey the highest (cited by Lang, 2008) levels of immunoglobulins. No information is available regarding local Indian breeds.

First lactation heifers usually have lower levels than older cows that are in their third or greater lactations. Therefore this is one of the reasons that the calves born to the younger cows are more prone to disease than calves from older cows. Cows at better body condition at calving have been shown to impart more passive immunity to their calves. It has been shown (Selk, 2006) that the calves born from cows with lower body condition had lower amount of circulating antibodies, at 24 hours of age, than the calves born from heifers with adequate to good body condition score at calving.

Dietary energy and protein concentration late in gestation have little effect on the iimmunoglobulin concentration in colostrum, provided the requirements of these nutrients are met. However, providing dry cows with appropriate amounts of macro and micro minerals, which include selenium, along with vitamin A, D, and E will help ensure adequate levels in the colostrum (Waterman, 1998). Supplementing dry cow diets with vitamin E and slelenium are important for udder health at calving. The number of colostral antibodies which fight scour causing organisms such as *E.coli* can be increased by vaccinating the cow before calving. The vaccine should be given between 50 days to two weeks before calving to have optimum level of antibodies. Adoption of appropriate vaccination programme may help in the transfer of specific immunoglobulins to colostrum and provide immunity to calves. The length of dry period may also cause variation in immunoglobulin concentration. Cows, which have less than a 4-week dry period, usually show lower levels of antibodies

(Foley and Otterby, 1978). Timing of colostrum feeding is very important for a successful colostrum management programme. It has been shown clearly that the absorption of very large antibody molecules must take place in the first 24 hours of life. By the time the calf is 6 hours old, only 66 percent of the antibodies consumed can be absorbed. When the calf is 12 hours old, less than half of the available antibodies will be absorbed into the blood, and when the calf is 24 hours of age, intestinal closure is nearly complete (Selk, 2006). Anything that compromises the vigor of the calf (e.g. difficult birth) can have an adverse affect on passive immunity. Shape and size of the udder of the dam may also influence the transfer of passive immunity (Goodier and Williams, 2005). Cows with large pendulous teats and /or with very low udder attachments may be difficult for the calf to locate and get the teat in its mouth to nurse. Therefore the method of feeding colostrum is important for better availability of immunoglobulins to calf.

How much and how to feed?

The goal of proper colostrum feeding is to achieve a minimum blood serum IgG level greater than 10 mg/ml. To achieve this level, as a general rule, a calf should be fed at the rate of five percent of its body weight as soon as possible after birth and the same amount again about 6 hours later (Thomas, 2002). Feeding of colostrum or transition milk should be continued for the first 3 days.

We should not rely on the calf to nurse from the dam. Most calves do not consume adequate amount of colostrum. The studies have shown that the udder conformation of the dam can affect time to first suckling. Calves born to dams having udder floors 2 feet or less, above the ground delayed first suckling by nearly 4 hours. The delay time increased as udders became more pendulous and moved closer to the ground (Goodier and Williams, 2005). Using a nipple bottle or oesophageal feeder let one know exactly how much the calf has consumed. The calves should not receive milk or elelctrolytes before colostrum, because this will decrease the absorption of antibodies. Recent studies have shown that there is a life iong impact of inadequate availability of colostrum (feedindustrynetwork.com).

Handling and storage of colostrum

For optimum results, colostrum should be collected from cows within 24 hours of calving and fed fresh. High quality colostrum can be stored in a freezer for over one year without loss of quality (Foley and Otterby, 1978). The colostrum from two or more cows should not be mixed. It should be frozen in small amounts of approximately 500 to 750 ml self-seal bags and should not be thawed rapidly. Thawing is generally recommended in warm water. It should be stirred frequently to ensure even thawing and warming. Overheating can denature the immunoglobulins and affect the quality of colostrum. The frozen colostrum should not be thawed at room temperature, because the bacteria double every 20-30 minutes at room temperature. Once thawed, colostrum should not be refrozen. Recent research at university of Minnesota has shown that colostrum could

be heated to 60°C without damaging the antibodies. However, heating at 63°C reduces antibodies by 34% (McMartin *et al.*, 2006).

Colostrum substitutes and supplements

There is no substitute of true colostrum. In case the colostrum is not available, the colostrum from female form the same flock is the best source because it will have 'custom-made' antibodies. In many countries, colostrum substitutes are available in the market. They are however, not recommended to replace colostrum. In India the colostrum substitutes are not readily available. So the colostrum may be preserved for use in emergencies or the calves may be offered the substitute prepared by mixing the following ingredients:

1. Water	275 ml
2. Egg	1 (55 g)
3. Castor oil	½ teaspoon
4. Boiled milk	525 ml
5. Vitamin A	10,000 I.U.
6. Auromycin	80 mg

(Source: Reddy, 2006).

However, this substitute does not have any antibodies. So the use of preserved colostrum should be preferred over the use of this substitute.

Interaction of colostral immunity with active immunity

The calves loose their temporary immunities by seven to eight weeks of age, or even earlier, which depend on the strength of passive immunity, gained through colostrum feeding. High level of maternal immunities, effectively neutralize any invading organisms, and so the calf's own immune systems are not stimulated to develop until that protection begins to diminish.

The antibodies gained through colostrum can interfere with effectiveness of vaccines. If a calf is vaccinated at a younger age, while it still has high levels of maternal antibodies, its immune system will not respond to the new antigen of vaccine because the maternal antibodies neutralize them. So vaccines given to a calf when it is only two-three weeks old will not give it any protection, since it will not stimulate immune system. Most vaccines should be given at 8 weeks of age or older, and repeated with a booster shot two to six weeks later to make sure the calf's immune system responds to the antigen.

Biosecurity

Sometimes due to some reason we may have to use colostrum from other cows or from some other farms. While using colostrum from other farm, we could be at a risk of obtaining a new disease. Johne's disease could spread to the herd through infected colostrum. So it is important that the cow, from which colostrum is obtained, should be free from TB, and Johne's disease.

Colostrum for lambs and kids: like cows, ewes and does also produce colostrum for about 24 hours after lambing/kidding. The colostrum should be consumed as early as possible. Thirty minutes are considered optimum whereas 18 hours is considered a must (Arguello *et al.*, 2004). It is important that the colostrum should be fed @ 10% of their body weight before the age of 24 hours, at body temperature. It has been shown that

heating colostrum at 56^{0}C for 30 minutes decreased total protein levels, gamma globulins and serum IgG levels in kids (Fernandez *et al.*, 2006). The kids can be allowed to suckle or hand fed with a bottle and nipple (Arguello *et al.*, 2004). Hashemi *et al.* (2008) reported that, like bovine, better body condition of the ewes, fed 110% of NRC requirements for two months before lambing increased colostrum quantity, decreased the ewe loss and increased lamb birth weight and there was a significant ($P< 0.05$) correlation between IgG levels of the ewe serum and colostrum. However, plane of nutrition does not affect the IgG concentration of ewe colostrum and serum. Cow colostrum can be used as a substitute of ewe or goat colostrum, but because cow-milk is comparatively less nutritious compared to ewe's milk, more volume (about one third) should be fed to lambs and kids. Care should be taken about the risk of transmitting Johne's disease to the kids and lambs. Pregnant females should be kept in location where they are going to lamb or kid for at least 14 days prior to parturition. This will give them time to prepare the specific antibodies for their specific lambing and kidding environments. Lambs are borne with low vitamin A reserve. Colostrum is usually rich in vitamin A and help to build stores in the new born. Vitamin A also provides immunity to the newborn. The ewe and goat colostrum can be stored in a freezer and used when required. It has been shown that the peak IgG levels are achieved earlier when offered frozen colostrum than when offered refrigerated colostrum (24 hours vs. 36 hours) to kids (Arguello *et al.*, 2004).

Colostrum for piglets

Like most of the mammals except humans, no antibodies are transferred through the placenta to the baby pigs before birth. Normally, pigs are born in a vulnerable state without any mucosal associated antibodies and no acquired cell mediated immunity. The mortality rate in piglets is affected by the consumption of colostrum. Large litters, long farrowing times, and the suckling behaviour of the piglets may negatively affect the ability of late born piglets to consume sufficient quantity of colostrum. The pigs born later in litter or smaller piglets have low levels of serum IgG levels in their blood and upto 6% death rates in piglets can be attributed to the poor absorption of colostrum (Lews and Kyle, 2001). Although the composition of sow colostrum is well known, yet it is only recently that the presence of valuable bioactive compounds, which can either protect piglet from infection or modulate their metabolism was detected in colostral secretions (Farmer *et al.*, 2006). Neonatal swine can efficiently use colostrum since they have a remarkable capacity to deposit large amounts of fat and can also absorb intact immunoglobulins for 24 hours postnately. The passively acquired colostral antibodies in the blood gradually decrease from initial level by about 10-14 days although they may persist at a protective level against most pathogenic antigens for 6 to 12 weeks.

The colostrum provides immunity to pigs against various types of infections such as streptococci. The abscess development in pigs exposed to streptococci at 5 and 14 days of age was hindered in pigs fed colostrum whereas the colostrum deprived pigs showed lymphadenitis on postmortem (Wood *et al.*, 1986). There are indications that the composition of colostrum can be altered by some management components such as the composition of feed of the dam, the cleanliness of the environment etc. (Farmer *et al.*, 2006). The minimum threshold requirement of colostrum by piglets is unknown. However a general consensus is that piglets must consume 150-280 g/kg body weight soon after birth. In order to ensure a fair share of colostrum to each piglet, cross fostering should take place as soon as possible following birth, ideally across sows within 24 hours or sooner after farrowing. If porcine colostrum is not available bovine colostrum can be used as a substitute.

Colostrum for puppies and kittens

Making sure a newborn pup or kitten receives colostrum will give it a great start on the way to a happy and healthy life. Because water makes up 75-80% of the newborns body weight, dehydration is a serious problem especially in puppies. Besides providing immunoglobulins and nutrients, it helps in maintaining the fluid level in puppies. Dogs and cats, like many other mammals, pass majority of mother's antibodies to the newborn via colostrum. It is worth mentioning that the puppies and kittens will only receive antibodies against diseases for which the mother had been recently vaccinated or exposed to. For efficient immunity, the puppies must receive the colostrum within 24 hours of age. The age at which the young puppies are to be immunized depend on the amount of antibody protection they received from their mother. High level of maternal antibodies present in a young animals blood stream will interfere in the effectiveness of vaccine. When the maternal antibodies level decreases to a low enough in the animals, immunity can be produced through vaccination. There is a period of time from several days to several weeks in which the maternal antibodies are too low to provide protection against the disease, but too high to allow vaccine to be effective. This period is called the window of susceptibility. This is the time when despite being vaccinated, a young animal can still contact disease. The length and timing of window of susceptibility is different in every litter, and even between individuals in a litter. It is also to be remembered that a young animal may have a protective titer for one disease but not for the other. The cats also have a colostral phase of lactation (Melisa *et al.*, 2006). The authors also reported that the total IgG and IgA concentration in milk were significantly ($P< 0.05$) higher on day of parturition than on day 7 of lactation and the protective concentration of immunoglobulins could be restored in kittens with failure of passive transfer of

immunity by parentral administration of adult serum, but not by fostring on queens in mid-lactaion. In case of unavailability of colostrum cow colostrum can effectively be used for puppies and kittens.

Summary

The first milk is nearly equivalent to blood in terms of nutritive value and is called colostrum. It should be fed to new born within 24 hours of birth. It can be stored in a fridge for one week and in a freezer for one year. Peak antibodies levels reach earlier by using frozen colostrum as compared to refrigerated colostrum. Cow colostrum is not species specific and can be fed to all the species. Presence of maternal antibodies interfere in the effectiveness of vaccines. Care should be taken while using colostrum from other farms, that the farm should be free from Johne's disease and Tuberculosis.

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