



Bovine colostrum: Neonate to nutraceuticals

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ABSTRACT : Colostrum is the first milk produced by mammals within a 24 to 72 hour period after parturition. Colostrum contains various proteins, carbohydrates, fats, vitamins and minerals that are essential for the diet of a developing mammalian neonate. It also includes bioactive constituents such as immunoglobulin, antimicrobial peptides and growth factors. Colostrum and fractions thereof may be useful for treatment of a variety of health conditions, including gastrointestinal disorders, respiratory tract disorders, viral and bacterial infections and tissue repair. Bovine colostrum is sold commercially as a nutraceutical products and it purports numerous health benefit. Harvested colostrum is generally dehydrated by either spray drying or freeze-drying. Dried colostrum is widely used for pharmaceuticals to improve long-term storage of unstable drugs. The various traditional colostrum products like *Kharwas*, *Kalvdans*, *posu*, *Soyi Posu*, yoghurt and commercial colostrums products like powder, Whey protein Powder, Tablets and Lozenges are also made / available in the market.

KEY WORDS : Bioactive substances, Colostrum products, Colostrum powder, Drying method

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INTRODUCTION

The thick, first milk produced by mammals after parturition is called colostrum. Due to its nutritional richness it is sometimes called 'Liquid Gold'. Colostrum is the first mammary gland fluid secreted by all mammals following the birth of the young. Colostrum can be considered to be 'life's first food' for young mammals. It is the nutrient-rich, first secretion produced by mammals within 24 to 72 hours after parturition. Colostrum contains various proteins, carbohydrates, fats, vitamins and minerals that are essential for the diet of a developing mammalian neonate and all group of person. The composition of colostrum provides immediate immune protection to the newborn. Colostrum also includes bioactive constituents such as immunoglobulins, antimicrobial peptides, growth factors and nutritional components listed in Table 1. These bioactive components are not just restricted to colostrum, but are found

in a lesser degree in milk and whey products. Due to availability of large amount of bioactive components in colostrum it gives several health/nutrition outcomes as given in Table 2.

Bovine colostrum is sold for use as a nutraceutical product. Hardy (2000) defined nutraceuticals as "any food or ingredient that has a positive impact on an individual's health, physical performance, or state of mind, in addition to its nutritive value". Approximately, 5- 10 litres of colostrum per milking are normally obtained from a dairy cow (Moore *et al.*, 2005). The typical dairy cow produces more colostrum than is consumed by the calf and in commercial bovine colostrum operations, this excess colostrum can be processed for nutraceutical products (Moore *et al.*, 2005).

Current research has indicated that bovine colostrum is commonly used as a raw material to produce immunoglobulin-rich, bioactive commercial products. Since similar biologically active molecules of human colostrum also are found in bovine colostrum, scientific researchers and nutraceutical companies are studying the effect of whole and fractionated bovine colostrum on various human illnesses and for food processing industries. Colostrum is vital to human development through its role in infant health and nutrition. Colostrum provides immunological protection and establishes gastrointestinal micro flora balance (Xu and Wang, 1996).

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Colostrum delivers its nutrients in a very concentrated low-volume form. These nutrients provide protection against pathogens as well as assistance with development of the gastrointestinal tract (Xu and Wang, 1996).

The beneficial and medicinal nature of bovine colostrum was well-known by ancient cultures; however, it is only until recently that scientific research has begun purporting the experimental and clinical uses of bovine colostrum and its bioactive components. Xu and Wang (1996) reported a method to produce bovine colostrum antibodies against 17 specific enteric pathogens including 12 *E. coli*, 2 *Salmonella* and 3 *Shigella*. Colostrum has many functions and properties which makes it most probably the 'single most important food in the world' (Hardy, 2000). Colostrum has the ability to fight numerous disorder and disease. It is cost effective and safe treatment to prevent many ailments. Colostrum properties help to improve gut condition. Colostrum supplement treated gut epithelial cells divides faster and produced more cells than untreated culture. When mucosal injury happens, the surrounding cells lining the gut wall is attempted to fill the wounded area, the migration of gut epithelial cells increased when treated with colostrum. The repair happened faster in the presence of colostrum. The proliferation index for production of Gut Epithelial cell is two times faster in colostrum supplement. Colostrum is beneficial for Prevention of Flu Episodes as compared to vaccine. Colostrum is at least 3-times more effective than Flu Vaccine alone (Cesarone *et al.*, 2007). It have Anti-inflammatory activity, Capacity to recovery from auto-immune illness, capacity to increase nutrients uptake, antibodies against allergens of clinical importance to humans, rich in antioxidants, athletic

performance, skin health and wound healing, increased brain function, helps to prevent heart disease and cancer.

Considering all above distinctiveness of colostrums various traditional and commercial products are made available to consumers. A systematic description of all the aspects of such products is given in following paragraphs.

Use of colostrum: Historical perspective :

For many centuries, the benefits of colostrum were debated. Instead of colostrum infants were advised to feed mixture of honey, clarified butter, plant juices, and gold dust for the first few days after birth in India during the fourth century B.C. During the first century A.D., Soranus of Ephesus (a Greek physician), advised parents to feed newborn children boiled honey and goats milk as a first food rather than colostrum. However, by the end of the seventeenth century A.D. and the beginning of the eighteenth century A.D., the beliefs about colostrum began to slowly change (Stuart-Macadms and Dettwyler, 1995).

Ayurvedic physicians and naturopathic healers have used bovine colostrum for thousands of years for medical treatment of certain skin and eye infections. During the eighteenth century, the English physicians William Cadogen and William Moss advocated giving colostrum to an infant after birth. Cadogen and Moss noted that replacement infant foods were correlated with abdominal distress and/or gastrointestinal infections. In 1892, the German scientist Paul Ehrlich confirmed that antibodies are transferred to a newborn animal by colostrum and in 1950, physician Albert Sabin discovered that colostrum contained antibodies against polio (Stuart-Macadms and Dettwyler, 1995).

Table 1: Components of colostrum

Immune system factors	Growth factors	Nutritional components
Immunoglobulin	Epidermal growth factor (EGF)	Vitamins
Lactoferrin	Transforming growth factor(TGF)	Minerals
Proline-Rich polypeptides (PRPs)	Insulin-like growth factor (IGF)	Amino acids
Lactoperoxidase	Fibroblast growth factor (FgF)	Fats
Lysozyme	Growth hormone (GH)	Protein

(Knight *et al.*, 1988; Pakkanen *et al.*, 1997)

Table 2: Importance of bioactive compounds of colostrum

Actives	Amount	Health/nutrition outcomes
Broad-range specificity Immunoglobulin (IgS)	20-150 g/l	Immunoglobulin bind bacteria and other antigens before these enter blood, tissue and organs and help their elimination
Proline-rich-peptide (PRP)	3 g/l	Immune modulation, cognitive enhancement, thymus regulation
Epidermal growth factor (EGF)	4000-8000µg/l	Stimulate s the repair process at sites of injury
Insulin-like growth factor-1 (IGF-1)	50-2000µg/l	Sports nutrition, lean body, cell and tissue repair and rejuvenation ,
Insulin-like growth factor-2(IGF-2)	200-600µg/l	stimulating DNA formation
Transforming growth factor (TGF)- 2	100-300µg/l	Cell protection, cell proliferation, immune enhancement

(Pakkanen *et al.*, 1997)

Traditional colostrum products:

In India, especially in Maharashtra, colostrum is used to prepare a popular sweets gel preparation called as 'Kharwas'. Diluted colostrum is mixed with sugar and flavoured with cardamom and saffron. This mixture is then heated in boiling water bath till gel formation occurs. The gel so formed is cut into small pieces (Kulkarni and Pimpale, 1989). The gel obtained with the first milking are very tough and, therefore, it is common practice to dilute the colostrum appropriately with milk or water to obtain gels of suitable consistency. Usually cane sugar is added @ 8% and brown sugar is added @ 12.5% in *Karwas* preparation to impart the desired sweetness.

The traditional sweet *Kharwas* is popular in *Konkani* and *Kannada* by the name of *Posu* and *Ginnu*, respectively. Sometimes the fresh grated coconut is mixed instead of milk to a portion of the colostrums in manufacturing of colostrum based traditional products called *soyi posu*. Word *soyi* is derived from *konkani* which means coconut.

'Kalvdan' is the colostrum product of Sweden. Equal quantity of milk and colostrum are mixed and heated in water bath at temperature ranges between 75 to 90° C. Sugar, salt, and cardamom are added as per taste (Rudbo and Angmo, 1989).

Colostrum yogurt from Holstein cow colostrum with

different ratio of colostrum and milk level was reported by Elfstrand (2000). The process flow diagram is shown in Fig.1.

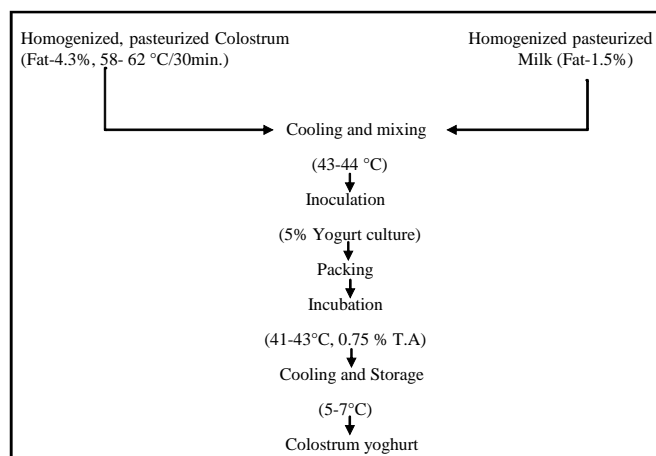


Fig. 1: Flow diagram of colostrum yoghurt (Elfstrand, 2000)

Preparation of *panner* and *chhana* using different level of milk and colostrum collected from 1st to 7th milking of *murrah* buffaloes and crossed breed cows was reported by Kadian (2000). The colostrum and milk ratio were 100:0, 90:10, 80:20, 70:30,..... so on with @ 0.5%, 1%, 1.5% citric acid used. The

Table 3: Commercial available colostrums' products

Products	Company	Features
Colostrum lozenges	A penny saved Enterprises, U.S.A	Nutritional supplements
Colostrum powder		
Colostrum Capsules	Health world, U.S.A	Maintenance against cold and infections
Colostrum Lytes	Natural wellness, U.S.A	Auto-immune enhancer(sport food)
Dynamic Colostrum™	Hi-Col Oy, Finland	Positive effects on health, fatigue and antimicrobial properties
Gastric Colostrum™		
B - Colostrum™	Biostrum Nutritech Pvt. Ltd., India	Oral immunoglobulin
Lactimmunglobulin Biotest	Biotest pharma GmbH, Germany	Treatment of diarrhea in AIDS patients
Gastrogard-R™	North Field laboratories, Australia	Prevent rotavirus diarrhea
Colostrum beauty cream	Alpha Lac®, Inc	Skin cream (cosmetic)
Demelle	Vitamed, Norway and Macranova, Sweden	Skin cream, anti aging effect
CuraMed	CuraMed as, Norway	Tablets against throat and mouth infections
Colostrum chewable tablets	Nutra Vive, NZ	Cold pressed tablets
Nature's Gift@Colostrum	Sterling Technology, South Dakota, Toronto	Hand and skin moisturizer, contents IGF-1
Emollient ointment		
Colostrum-IX	Green Better Living Company, U.S.A	Natural nutritional food supplements
Bioenervi™	Viable Bioproducts Ltd, Turku, Finland	Sports foods, (provide growth factor during strenuous activity)
Demand 2000	Sydinnovator and partners, Sweden	Skin cream (anti-aging effect)
Millennium Force	Green Better Living Company, U.S.A	Sport and nutritional drink
Intact™	North Field laboratories, Australia	Nutritional food supplements powder
High-Immunoglobulin Colostrum	Symbiotics, LLC, Sedona	Enhance body immune function
Enlight	Nutra Vive, NZ	Ready to blend instant powder (protein drink)
Super high potency colostrum	Solocare pharmaceuticals, Milwaukee, WI	Tablets against enhances immune system, burn fat and build muscle mass

(Elfstrand *et al.*, 2002; Das *et al.*, 2013)

pressing time 15 to 30 minutes were used for *panner* making. The processing steps reveals that milk and colostrum ratio 80:20 from 2nd milking of cow and 20:80 from 7th milking of buffalo for colostrum *paneer* preparation using 30 minutes pressing time, 40 minutes dipping time and 30:70 from 7th milking of cow and 20:80 from 7th milking of buffalo for colostrum *chhana* were selected on the basis of sensory attributes. Development of these colostrum products resulted in an enhanced percentage of fat, total protein, calcium, phosphorus and iron content.

Commercially available colostrum products:

The different type of colostrum concentrate have prepared on large scale production. These are in the form of tablets, powder, lozenges and Powder beverages fortified with colostrum. A detail list of colostrum products commercially available worldwide is given in Table 3 along with specific features of each products.

Manufacturing of colostrum products:

Considering the fact that colostrum and its components are very sensitive to heat and other environmental conditions manufacturing of products from colostrum requires special care and attention. The critical areas where special attention is required for successful processing is given in following paragraphs.

Selection of colostrum:

The quality of colostrum is referred to its concentration of immunoglobulin. If the immunoglobulin/ml > 60mg (or >30mg IgG1/ml) then colostrum is considered as good quality (McGuirk, 1998). According to Pritchett *et al.* (1991) IgG1/ml content should be greater than and equal to 35 mg.

The quality of colostrum can be estimated quickly with a 'Colostrometer' (Fleener *et al.*, 1980). Measuring of quality of colostrum by Colostrometer is based on colostrum specific gravity as shown in Table 4. The colostrometer is used on colostrum at a temperature of 20°C for greater accuracy. If the measurements are carried out at lower temperature, uncorrected readings over estimate colostrum IgG concentration while measurements made in warmer colostrum under estimate the immunoglobulin concentration (Mechor *et al.*, 1992). Colostrometer gives the linear relationship between colostrum specific gravity and immunoglobulin concentration *i.e.* globulin concentration increases with specific gravity and *vice-versa*.

Table 4: Measuring of quality of colostrum by colostrometer

Specific gravity	Quality	Globulin(mg/ml)
1.027 to 1.035	Poor	1.42 to 21.80
1.036 to 1.046	Moderate	24.35 to 49.82
1.046 to 1.076	Excellent	52.36 to 126.62

(Elfstrand, 2000)

The good quality of colostrum is referred to commercial processing. Temperature and time are both important in maintaining IgG activity in colostrum. The higher the temperature, the shorter the time it takes for the IgG to become completely denatured.

Pasturization of colostrum:

Harvested colostrum (whole colostrum) is pasteurized at 60°C for 30 minute. Pasteurizing colostrum using the conventional methods and temperatures are typically used to pasteurize milk yielded unacceptable results. Batch pasteurization at 145°F or 63°C/ 30 min. resulted in only mild thickening. However, high temperature, short time continuous flow pasteurization, HTST at 161°F or 72°C/15 sec. resulted in severe thickening or congealing of the colostrum and plugging of equipment.

Both batch and HTST pasteurization resulted in denaturation of approximately 1/3rd of IgG in colostrum (Godden *et al.*, 2003). More recent research has determined that problems with thickening or IgG denaturation can be avoided by using a lower-temperature, longer-time approach to pasteurize colostrum. In most situations, heating colostrum at 140°F (60°C) for 60 minutes in a commercial batch pasteurizer should be sufficient to maintain IgG concentrations (McMartin *et al.*, 2006; Godden *et al.*, 2006). Effects of temperature on colostrum IgG concentrations (mg/ml) for 30 batches of pre pasteurized colostrum were noticed 76.4 at 60°C and 77.1 at 63°C whereas for post pasteurized colostrum 74.5 at 60°C and 46.5 at 63°C. Other components of colostrum likewise can withstand pasteurization but not higher temperatures. Insulin-like growth factor (IGF) can withstand 79°C for 45 seconds but not 121°C for 5 minutes. Lactoferrin one of the major colostrum proteins with antimicrobial and many other effects is unaffected by pasteurization, but UHT treatment decreases its ability to bind various bacterial species and destroyed its ability to inhibit bacterial growth. Pasteurization reduces mineral content (iron, copper and zinc) but not to a significant degree. Sufficient levels remain in the colostrum to meet the needs of the infant.

Colostrum drying:

Pasteurized colostrum is dried by both spray drying and freeze drying process for manufacturing of different category of powder. Spray-drying allows a liquid product to be atomized and contacted with a hot gas to instantaneously obtain a powder. Commercially, spray-dry processing of colostrum is up to 2.5 times less expensive than freeze-dry processing (Chelack *et al.*, 1993).

Spray drying bovine colostrum is conducted at a low temperature thereby allowing minimal loss of immunoglobulin function and quantity (up to 94%). Although immunoglobulins activity is well conserved, a disadvantage to spray drying is a 25 per cent loss of total solids from the colostrum (Chelack *et*

al., 1993). The spray-drying of colostrum is the same method used in the manufacture of dried milk. Colostrum is first diluted with demineralised water until T.S reached to 11-13 per cent. Diluted colostrum is pasteurized and evaporate to T.S 48- 50 per cent, then processed under spray drying. The technical data of mini spray dryer having flow rate 160 ± 20 ml/hr is described in Table 5.

Table 5: Technical feature of spray dryer for colostrum

Technical features	Parameter/regime
Type of dryer	Electrical dryer
Type of flow	Co-current
Atomizer inner diameter	0.47mm
Atomizer pressure	0.7 ± 0.01 Mpa
Inlet fed temperature	32 ± 1 °C
Inlet temperature	125 ± 1 °C
Outlet temperature	48.9 ± 1.3
Flow rate	160 ± 20 ml/hr
Glass transition temperature	40 °C
Moisture content	3.83 g H ₂ O/100g of dry solid

(Huaning yu *et al.*, 2013)

Chelack *et al.* (1993) reported the lengthy process of freeze-drying or lyophilization is the most effective method for preservation of immunoglobulin function and minimal loss of total solids. The process of freeze drying is widely used for pharmaceuticals to improve long-term storage of unstable drugs (Chelack *et al.*, 1993). Freeze drying utilizes low temperatures, along with rapid dehydration of a liquid product. This technique allows for a reduction of protein denaturation in the product as compared to spray drying. According to Elfstrand *et al.* (2002) the process of freeze-drying bovine colostrum concentrate decreased the amount of native IgG1, IgG2 and IgA by 25 per cent compared to colostrum whey. The freeze-dried colostrum whey had decreased IgG2 and IgA of 35–40 per cent, while IgG1 only was reduced by 17 per cent. Comparison between the drying methods under different parameters and regime are listed in Table 6.

Table 6: Comparison of drying methods

Parameter	Freeze drying	Spray drying
Process efficiency (T.S)	100 %	75 %
Immunoglobulin function	Most effective preservation	Less effective preservation
Protein denaturation	Less	More
Loss of IgM	2 %	Complete loss
Growth factor (TGF- 2, IGF-1)	Reduced up to 30%.	More than 50%
Production rate (Kg/hr)	0.15	11.2
Antibody retention (%)	99	94
Energy used (KWH/Kg)	1.52	0.68

(Chelack *et al.*, 1993; Elfstrand *et al.*, 2002)

When whole colostrum is dried under these processes, the finished product is called whole colostrum powder. Skin colostrum powder are prepared by separation of lipid fraction from whole colostrum by centrifugation process further followed by spray drying and freeze drying.

Colostrum whey is prepared from pool colostrum by renneting at 32° C for 30 minutes before cutting (rennet strength 1:15000, chymosin/pepsin ratio of 75/25). The colostrum whey is further directly heat-treated or micro filtered before heat treatment followed by freeze-drying. These processing steps resulted in two different preparations called colostrum whey powder and colostrum concentrate powder, respectively (Fig.2) (Elfstrand *et al.*, 2002).

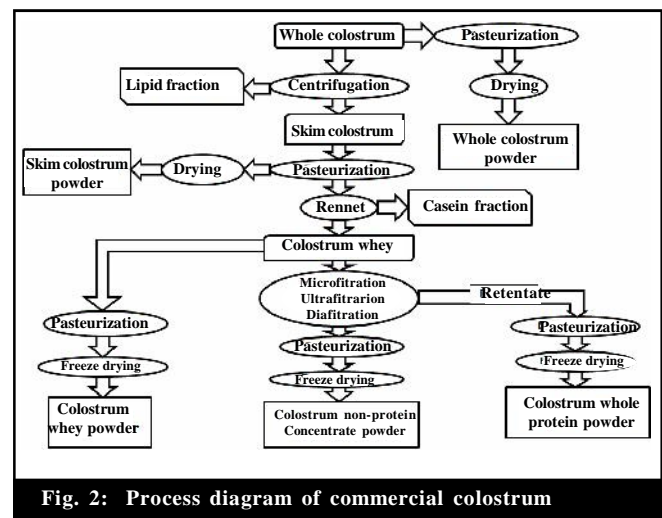


Fig. 2: Process diagram of commercial colostrum

The colostrum concentrate is prepared from the colostrum whey by microfiltration having ceramic membrane, pore size 0.8 mm. at an average 30° C, ultra filtration and diafiltration are carried out on cut-off of 100 kDa at an average 20° C (Lindstrom *et al.*, 1994). Colostrum whey and colostrum concentrate are pasteurised batch-wise at 60° C for 30 min. and then freeze-dried.

Packaging and storage of colostrum and colostrum products:

The colostrum are immediately frozen and stored at -20°C for one year without affecting bioactive properties (Elfstrand *et al.*, 2002). Colostrum is stored at 4°C in plastic (polypropylene) containers to maintain its protective quality. Plastic container (polypropylene) is superior to steel with respect to viability and total count of milk cells (Manohar *et al.*, 1997). The probable reason for greater reduction in cell viability in steel could be due to the oligodynamic action of nickel which is present in such containers resulting in cytolysis of milk cells when stored in steel containers over a prolonged time.

Powder forms of colostrum are packed in polyethylene terephthalate (PET) and aluminum laminated polyethylene (ALPE) pouches. Colostrum powder is also packaged in a 200 g HDPE bag and stored in an air tight tin container at $30 \pm 2^\circ\text{C}$ (Kulkarni and Pimpale, 1990). Colostrum proteins are hygroscopic and can absorb odors. Temperatures below 25°C, RH below 65 per cent and an odor free environment will extend storage life (Manohar *et al.*, 1997). Shelf-life of colostrum powder is about 6 to 24 months if stored under specified conditions.

Conclusion:

Colostrum is collected fresh and processed immediately. Low-heat processing techniques of colostrum have a minor loss of bioactivity substances. From this stage it is manufactured into various products. The major biologically active components of colostrum *i.e.*, immune helper and growth factors show great influence on health aspects and varieties of colostrum products are manufactured on both traditional and commercial scale, using different processing technology. Colostrum is sold commercially as a nutraceutical that purports numerous health benefits. This is the nature's gift that is for the young ones to grow as well as for the treatment of many health problems in older age group.

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