Food Science and Technology
ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.14619

Bovine colostrum: benefits of its use in human food

Emerson Gabriel dos Santos Oliveira SILVA[1], Adriano Henrique do Nascimento RANGEL[1], Lisandra MÜRMAM[2], Maria Fátima BEZERRA[3], Juliana Paula Felipe de OLIVEIRA[4*]

Abstract

Colostrum is the first secretion of the mammary gland produced after birth, differentiating itself from mature milk because it has a higher concentration of proteins, immunoglobulins, vitamins, minerals, bactericides (lactoferrin, lysozyme and lactoperoxidase) and growth factors. The use of bovine colostrum for human consumption has been registered for many years in food or in medicinal therapies, and several studies have been conducted with the objective of evaluating its benefits in human food supplementation. The results point to improvements in cases of gastrointestinal, respiratory, inflammation, and bone development diseases, among others. Its commercialization currently takes place in physical or online markets in some countries. However, its commercialization for human consumption in Brazil is very recent, placing bovine colostrum as a new functional food option for consumers.

Keywords: functional food; bioactive compounds; lactoferrin; lysozyme.

Practical Application: The most recommended industrial application in food production is in the dairy industry in developing food products with bioactive compounds favor human health benefits provided by improvements in the immune system, intestinal flora balance and tissue regeneration.

1 Introduction

The first secretion of the mammary gland after childbirth is known as colostrum, and its composition significantly changes in the first days, differentiating it from mature milk (Rathe et al., 2014). Bovine colostrum is a food having abundant composition in immunological agents which play a passive immunity role in the newborn, guaranteeing protection and assisting in developing the calf's gastrointestinal system (Nikolic et al., 2017). The antimicrobial factors present in colostrum act to protect the neonate against infections, especially in the first weeks after birth (Menchetti et al., 2016).

The use of human food supplementation should take into account variations in the composition according to species, breed, food management, number of calves, and processing practice, among others (Menchetti et al., 2016). Its composition is rich in solids, protein, immunoglobulins, fat, and growth factors, among others, having aroused interest for their inclusion in human consumption for both developing pharmaceuticals and food derivatives (Marnila & Korhonen, 2011; Yurchenko et al., 2016). Studies on the benefits of bovine colostrum for humans have been developed for centuries, although they are still not yet fully elucidated (Bodammer et al., 2011). In addition, in a review of equine colostrum, Barreto et al. (2019) also elucidated several benefits in food and human health.

Therefore, the present review aims to address the use of bovine colostrum for human consumption, taking into account its nutritional composition and the presence of functional compounds such as enzymes and growth factors. It highlights research showing human health benefits related to bovine colostrum supplementation.

2 Bovine colostrum composition

Colostrum is the first food of newborn mammals, being produced in the first days after birth. Its composition differs from mature milk because it presents a higher concentration of solids, protein, immunoglobulins, fat, and growth factors, among others (Marnila & Korhonen, 2011). The marked differences observed in bovine colostrum and mature milk compositions have evidenced different biological functions of the two fluids (McGrath et al., 2016). Colostrum composition varies by species (Gregory, 2003), as can be seen in Table 1.

The high fat and protein values for bovine colostrum (Table 1) are higher than the means found for fat (4.69%) and protein (3.62%) of mature milk (Czerniewicz et al., 2006). The high concentration of protein in colostrum is related to its high immunoglobulin concentration, which decrease during lactation until reaching the mean for this component in mature milk (Kamel et al., 2015). Different from the values observed for colostrum, the IgG and IgA immunoglobulins in mature milk represent 0.72 and 0.13 mg/mL, respectively (Gapper et al., 2007), demonstrating the importance of colostrum feeding by the neonate.

Received 26 May, 2019
Accepted 09 Sept., 2019
[1] *Programa de Pós-graduação em Produção Animal – PPGPA, Universidade Federal do Rio Grande do Norte – UFRN, Macaíba, RN, Brasil*
[2] *Unidade Acadêmica Especializada em Ciências Agrárias – UAECA, Universidade Federal do Rio Grande do Norte – UFRN, Macaíba, RN, Brasil*
[3] *Universidade Federal de Campina Grande – UFCG, Pombal, PB, Brasil*
[4] *Programa de Pós-graduação em Ciência Animal, Centro de Saúde e Tecnologia Rural – CSTR, Universidade Federal de Campina Grande – UFCG, Patos, PB, Brasil*
*Corresponding author: jupaula.oliv@yahoo.com.br

Evaluating the rheological characteristics of bovine colostrum and their correlation with IgG concentration, Ceniti et al. (2019) observed a significant decrease in solid-liquid balance and elasticity index values as well as in the IgG concentration was observed. A suitable correlation (R2 = 0.737) between the elasticity index values and the IgG concentration was evidenced. The study found suitable and valuable information towards understanding the rheological behaviour of colostrum at different times of milking. Thanks to the suitable correlation between the elasticity index values (obtained by microrheological evaluation) and the colostrum IgG concentration, Rheolaser Lab® technique can be proposed as a promising tool for the analysis of colostrum quality.

Colostrum has a significant amount of lactoferrin, lactoperoxidase and lysozyme in its composition, which have antimicrobial and antiviral characteristics. Lactoperoxidase acts on liposaccharide binding, regulating bacterial growth, while lactoferrin has toxic properties for a number of Gram-positive and negative bacteria, as well as antiviral characteristics, and lysozyme acts on the immune system, attacking the peptidoglycan component of Gram-positive bacteria, causing bacterial lysis (Pakkanen & Aalto, 1997). The antimicrobial, antifungal and antiviral actions of colostrum allow the destruction of certain pathogens such as *Escherichia coli*, *rotavírus* and *Cryptosporidium* (Bagwe et al., 2015).

According to Davison (2012), the immunological gain in using bovine colostrum in human feeding is due to the possible survival of some bioactive components in the digestion process which allow immune responses.

The use of colostrum for producing immunoglobulins on an industrial scale is interesting because it presents high bioavailability and safety when compared to blood derivatives (Anamika Das & Seth, 2017). The use of IgG, which is present in high quantities in bovine colostrum as an antimicrobial agent, differs from other conventional products because it does not result in changes in the intestinal microbiota, in addition to not favoring the emergence of resistant microorganisms (Steele et al., 2013).

In analyzing colostrum composition, Bagwe et al. (2015) and Marnila & Korhonen (2011) emphasize that bovine colostrum is an abundant source of fatty acids when compared to mature milk. Some fats present in colostrum, such as conjugated linoleic acid, play a role in preventing cancer (Godhia & Patel, 2013). The profile of unsaturated fatty acids in bovine colostrum can be seen in Table 2.

It can be observed that the lipid profile of bovine colostrum has lower concentrations for saturated fatty acids and higher values for monounsaturated and polyunsaturated fatty acids. In studying the fatty acid profile of bovine colostrum, Mašek et al. (2014) highlighted colostrum as a possible functional food alternative for humans due to its lower amount of saturated fatty acids when compared to milk, as well as the greater participation of unsaturated fatty acids such as linoleic-conjugated acid, which has beneficial characteristics for human health.

When studying the lipid components of bovine colostrum in the first 5 days after calving, Contarini et al. (2014) observed that the colostrum had a different fat composition in the first 24 hours than the fluid produced after four or five days and the milk of half lactation, highlighting an abundant concentration of essential lipids for the neonate such as omega-3 and phospholipids (mainly sphingomyelin) and cholesterol, while concentrations for trans fatty acids like linoleic-conjugated acid were lower in the first hours of production.

Table 1. Colostrum characterization of different species.

Constituent	Bovine Colostrum	Buffalo Colostrum	Sheep Colostrum	Human Colostrum
Fat (%)	6.7%	7.6 - 11.31	4.1	3-5%
Protein (%)	14.9%	4.3%	3.4	0.8-0.9%
Lactose (%)	2.5%	7.4%	4.7	6.9-7.2%
IgG1 mg/mL	35.0	NA	NA	NA
IgG2 mg/mL	16.0	NA	NA	NA
IgA mg/mL	1.7	NA	NA	NA
IgM mg/mL	4.3	NA	NA	NA
Lactoferrin mg/mL	0.8	NA	NA	NA

Source: Adapted from Czerniewicz et al. (2006), Bagwe et al. (2015) and Gapper et al. (2007). NA = not assessed.

Table 2. Unsaturated fatty acids profile in bovine colostrum.

Fatty acids	Colostrum	Mature milk
Palmitoleic C16:1 ω-7	1.57 ± 0.08	1.73 ±0.11
Oleic C18:1 ω-9 trans	0.76 ± 0.13	0.59 ± 0.06
C18:1 ω-9	39.28 ± 1.03	31.98 ± 0.81
C18:2 ω-6 trans	0.28 ± 0.04	0.31 ± 0.08
Linoleic 18:2 ω-6	6.53 ± 0.39	7.06 ± 0.44
Linolenic 18:3 ω-3	0.61 ± 0.04	0.43 ± 0.05
Gadoleic C20:1 ω-9	1.02 ± 0.14	0.75 ± 0.10
C20:2 ω-6	0.24 ± 0.04	0.20 ± 0.06
di-homo-y-linolenic C20:3 ω-9	0.17 ± 0.04	0.14 ± 0.03
C20:5 ω-3	0.86 ± 0.09	0.23 ± 0.03
Behenic C22:0	2.04 ± 0.15	2.31 ± 0.21
C22:2 ω-6	0.45 ± 0.09	0.25 ± 0.04
C22:5 ω-6	0.28 ± 0.01	0.28 ± 0.04
C22:5 ω-3	0.56 ± 0.02	0.20 ± 0.03
C22:6 ω-3	0.30± 0.06	0.23 ± 0.04
Nervonic C24:1 ω-9	0.53 ± 0.14	0.35 ± 0.06
Saturated Fatty Acid	45.71 ± 1.10	53.86 ± 1.18
Monounsaturated Fatty Acid	44.01 ± 0.79	36.69 ± 0.74
Polyunsaturated fatty acid	10.28 ± 0.66	9.45 ± 0.64

Source: Adapted from Zou et al. (2015).

The high concentration of bioactive components in bovine colostrum such as lactoferrin, lysozyme, leukocytes, immunoglobulins and cytokines guarantee immune protection until the newborn's body is able to develop its own responses (Satyaraj et al., 2013). These characteristics have attracted the interest of the pharmaceutical industry to bovine colostrum components and their applications in human health (Marnila & Korhonen, 2011).

Gosch et al. (2013) conducted a study aiming to determine whether membrane microfiltration can be applied to bovine colostrum for reduction in microbial content as it is applied in conventional milk processing. Standard industrial-scale ceramic membrane elements with various pore sizes and channel diameters were utilised in cross-flow microfiltration experiments to examine flux performance as well as the retention of micro-organisms and proteins. Additionally, comparative experiments with skimmed raw milk were performed. Although there are still some drawbacks that have to be dealt with, it has to be emphasised that cross-flow microfiltration is one of the very few methods that allows a considerable reduction in the microbial content of heatsensitive materials, such as bovine colostrums (Gosch et al., 2013). Regarding the concentrations of valuable substances such as IgG and lactoferrin, microfiltration with 1.4 and 0.8 lm provided a product that is close to the original raw material.

2.1 Benefits of immunoglobulin A (IGA)

Serum IgA concentration is 2-3 mg/mL, which makes it the second most abundant immunoglobulin in serum, behind only IgG with values of 12 mg/mL; however, IgA production by the organism is 5 times faster than IgG (Woof & Kerr, 2006). Salivary immunoglobulin (A S-IgA) plays a protective role in mucosal areas such as the respiratory tract, genitals and gastrointestinal tract, and is considered important in the defense against pathogenic invaders (Woof & Kerr, 2006).

Appukutty et al. (2012) studied the consumption of colostrum supplementation in adolescents involved in regular physical exertion. The authors observed that administration of 20 g of bovine colostrum supplement increased S-IgA production when compared to young women receiving a skim milk supplement.

Patıroğlu & Kondolot (2013) followed the use of bovine colostrum in treating children with upper respiratory tract infections due to IgA deficiency and observed a reduction in the severity of infections. The researchers emphasized that the patients did not report problems related to the use of colostrum.

2.2 Benefits of lactoferrin

Lactoferrin is a protein found in colostrum and breast milk (Buttar et al., 2017), and is considered the main protein found in milk serum of all mammals (Manzoni, 2016). It acts in preventing lung, bladder, colon, esophagus and tongue cancer by improvements provided to the immune system.

Lactoferrin has antineoplastic actions that act in different ways depending on the type of cancer; it can act in altering the cell membrane, cell cycle arrest, apoptosis action, metastasis inhibition and cellular necrosis. It is extracted from colostrum or produced by recombinant DNA technology, and is added to conventional formulas in certain countries because it is considered a safe food supplement by the Food and Drug Administration (FDA). Research has shown that lactoferrin has a high resistance rate to digestion (Manzoni, 2016), in addition to favoring benefits to infant intestinal health by reducing the pathogenic microbial load (Manzoni, 2016).

In vitro studies show that lactoferrin has inhibitory action against several viruses. Its oral administration in animals and humans showed satisfactory results against the common cold, influenza, viral gastroenteritis and herpes (Wakabayashi et al., 2014). In in vivo and in vitro studies conducted by Eliassen et al. (2002), lactoferrin showed cytotoxic activity against cancer cells, resulting in a significant decrease of tumors.

2.3 Benefits of lysozyme

Like lactoferrin, lysozyme is an enzyme that is present in bovine colostrum and acts as a bactericidal barrier destroying the integrity of the bacteria cell wall together with other bactericidal agents present in the colostrum (Ribeiro et al., 2016). According to Rainard & Riollet (2006), lysozyme is produced by epithelial cells and leukocytes, and performs bactericidal function by the hydrolysis of the peptideoglycans present in the cell wall of Gram-positive and Gram-negative bacteria causing cellular breakage.

In a study conducted by Davison & Diment (2010) to determine the effects of supplementation with bovine colostrum on neutrophil function and the release of salivary lysozyme after a resistance exercise known as acute depression of innate immunity, 20 male volunteers with mean age of 25 years were divided into two groups. One group received isoenergetic supplementation with bovine colostrum and another group with milk protein. The supplementation occurred for 28 days. On the 28th day the subjects were exposed to two hours of training on an ergometric system with electric brakes. In conclusion, the authors reported that daily supplementation with bovine colostrum during a period of 4 weeks increases the recovery of neutrophilic function, in addition to preventing salivary lysozyme release under immunosuppression conditions after physical exercise.

2.4 Human supplementation with bovine colostrum

Bovine colostrum has been used in human food for thousands of years in India, and in the United States its use as an antibacterial agent occurred until the development of antibiotics. However, in the 1990s there was an increase in research with the objective of using bovine colostrum for human consumption, as well as in developing products containing colostrum in their formulations (Jenny et al., 2010).

Historically, bovine colostrum use in India has occurred since the domestication of this animal species and is employed in both medical processes and spiritual rituals (Godhia & Patel, 2013). In India, colostrum is offered along with mature milk, presenting therapeutic action in the fight against influenza in older adult patients (Conte & Scarantino, 2013). Also in India, the use of bovine colostrum to irrigate the eye during surgeries in the ocular region is documented in an ancient Indian medicine known as Ayurveda (Buttar et al., 2017).

In the Western World, the use of colostrum in medicinal form dates from the 18th century, with its use aimed at improvements in the immune system. Colostrum was widely used in the fight against bacterial diseases until the development of penicillin (Godhia & Patel, 2013). Although it has beneficial properties to human health, therapeutic use of bovine colostrum in the past has been limited due to technical factors such as the oxidation sensitivity of colostrum lipid components and the need for cooling during storage (Struff & Sprotte, 2007).

In Brazil the commercialization of bovine colostrum for human consumption is prohibited by the Regulation of the Industrial and Sanitary Inspection of products of Animal Origin (Brasil, 2017). However, there are already studies with the objective of legalizing their commercialization, such as a technical report sent to the Ministry of Agriculture, Livestock and Supply (MAPA) and the National Health Surveillance Agency (*ANVISA*) on the use of bovine colostrum and its derivatives for human food. This material was developed by researcher Mara Helena Saalfeld, which was based on research carried out by the Technical Assistance and Rural Extension Company of Rio Grande do Sul (Saalfeld, 2015).

Colostrum performance in the human organism happens through the immune system due to its great bioactive component concentration, and in body development from the aid of its growth factors. As a result, its use as a food supplement in recent decades is increasing (Godhia & Patel, 2013).

Bioactive compounds favor human health benefits provided by improvements in the immune system, intestinal flora balance and tissue regeneration (Kabała-Dzik et al., 2017). In addition, bovine colostrum is employed in some therapeutic processes of cardiovascular diseases, allergies, autoimmune diseases and also presents beneficial actions against cases of bleeding, decreased flow and ischemia resulting from the administration of certain drugs (Bagwe et al., 2015).

The bioactive components present in bovine colostrum can present antimicrobial and neutralizing action of endotoxins in the gastrointestinal tract, fighting intestinal inflammation and aiding in repairs in cases of tissue lesions (Saad et al., 2016). Colostrum is more important in preterm newborns, since an immature organism has a reduced digestive function, low bacterial colonization and a dysregulated immune system (Sty et al., 2016).

Bovine colostrum is a potent immunological agent and has a rapid response against infections, so that its use may be an alternative to therapy with immune potential, especially for at-risk populations (Wong et al., 2014). A study conducted by Saad et al. (2016) with 160 children aged 1 to 6 years with acute upper respiratory tract infection or frequent diarrhea showed that patients who received bovine colostrum powder for 4 weeks benefited from a reduction in problems related to such infections, and a decrease in the number of hospitalizations was also observed. The obtained results led the authors to suggest administering colostrum as a therapeutic option against the evaluated infections.

In reviewing dietary supplementation with colostrum, Jones et al. (2016) concluded that bovine colostrum supplementation reduces the incidence of gastrointestinal problems in exercising adults. This result is important because extensive sports practice results in thermal and oxidative stress to the organism, and consequently can increase the intestinal permeability that will result in greater circulation of bacteria and toxins in the intestinal lumen, which in turn may deregulate the immune system and contribute to immunodepression caused by physical activity (Davison, 2012). In addition, increased intestinal permeability may be related to developing type 1 diabetes, Hashimoto's thyroiditis or diseases related to autoimmune hepatitis and autoimmune connective tissue (Wang et al., 2000). Supplementation with bovine colostrum reduces intestinal permeability (Hałasa et al., 2017).

Studies have shown that immune enhancement and exercise performance in individuals supplemented with bovine colostrum is limited and is not able to influence body composition during a period of intense training (Davison, 2012). However, other studies suggest gains in performance of athletes who practice frequent exercise, as well as improvements in recovery (Shing et al., 2009) and elevation in the reserve of antioxidant mechanisms which protect the skeletal muscle against oxidative lesions resulting from physical exercises (Appukutty et al., 2012).

Nutritional interventions to maintain the integrity of the intestinal barrier and, therefore, avoiding these complications during and following exercise in the heat are somewhat limited. However, bovine colostrum (Col) has shown to be both effective in blunting the heat-induced increase in permeability in vitro and in vivo in animals and humans. March et al. (2019) conducted the first study to demonstrate the efficacy of colostrum to reduce intestinal injury following exercise in the heat. This could hold particular relevance to athletes who are required to compete in hot and humid conditions and those individuals whose work (e.g. soldiers, firefighters) necessitates exhaustive physical exertion in such environments. (March et al., 2019).

Studies which have evaluated bovine colostrum supplementation in sporadic sports practitioners show that their use may be related to decreased fat, lean mass gain, strength gain, acceleration in the healing process and improvements in immune response, generally being affected after excessive exertion (Godhia & Patel, 2013).

Hałasa et al. (2017) observed a group of 16 female martial artists aged between 20 and 43 years in order to evaluate the use of bovine colostrum supplementation in athletes with intestinal permeability. One subgroup received supplementation based on 500 mg of bovine colostrum and another banana-based placebo twice daily for 20 days. The patients underwent a series of tests including fecal collections to assess intestinal permeability. The intestinal permeability in the group that received colostrum-based supplementation was reduced to limits considered normal.

Long-term high-intensity training can cause a decline in immune function in athletes. In this study, Zhang (2019) have explored whether bovine colostrums (BC) could improve the immune function in athletes undergoing intensive training. Thirty professional athletes were randomly divided into control group and bovine colostrum group; both groups received one month of intensive training. The control group received usual colostrum-free diet and the bovine colostrum group was fed bovine colostrum-rich milk every day. The results show that BC can increase the number of lymphocytes, an important cellular component of immune response. Also, BC increased the number of lymphocytes important for the regulation of immunity. After training, the albumin of athletes in the control group increased significantly, globulin decreased to about 21 g/L (normal value was 20-30 g/L), and A/G increased significantly. The serum albumin of the BC group did not change significantly.

Table 3. Studies using bovine colostrum in food production for humans.

Author	Product	Journal/Year
Ahmadi et al. (2011)	Yogurt	Journal of Agroalimentary Processes and Technologies/2011.
Ahmadi et al. (2011)	Yogurt and Kefir	JSM Biotechnology & Biomedical Engineering/2016.
Nazir et al. (2018)	Fermented milk	International Journal of Adv. Reserch in Sci. and Engineering/2018.
Abdel-Ghany & Zaki (2018)	Yogurt	Alexandria Science Exchange Journal/2018.
Anamika Das & Seth (2017)	Curd	International Journal of Chemical Studies/2017.
Mouton & Aryana (2015)	Ice cream	Food and Nutrition Sciences/2015.
Poonia & Dabur (2012)	Khees	J. Dairying, Foods & H. S./2012.
Saalfeld et al. (2012)	Milk drink and butter	*Agroecologia e Desenv. Rural Sustentável*/2012.

In summary, BC could prevent globulin deficiency caused by high-intensity training and improve the immune function of the human body.

Hung et al. (2018) studied the administration of bovine colostrum in treating rats with collagen-induced arthritis; a model adopted because of its similarity to human rheumatoid arthritis. The authors observed that colostrum use in the early stage of collagen-induced arthritis resulted in a modulating effect on inflammation markers and on arthritis symptoms. Such a finding may indicate that colostrum decreases symptoms caused by rheumatoid arthritis in rats, which suggests that the same may occur in humans.

Sty et al. (2016) conducted a study with the objective of evaluating the action of bovine colostrum obtained after the spray dry process on the intestinal function of preterm piglets. Although they observed a reduction in the composition of the TGF-β1 and TGF-β2 factors, there was an increase in intestinal villi, as well as a decrease in the severity of necrotizing enterocolitis cases.

Another benefit of colostrum is its ability to recover and aid in bone tissue development (Du et al., 2011). Bovine colostrum may contribute to lower limb gain and decrease bone resorption in older adults (Duff et al., 2014).

In a study by Du et al. (2011) with the objective of evaluating the effects of colostrum acid proteins on the bone loss of old rats, it was observed that colostrum supplementation is positive in preventing osteoporosis, which mainly affects postmenopausal women by causing imbalance between bone formation and resorption.

In a study by Antonio et al. (2001) to investigate the effect of bovine colostrum supplementation on active and healthy adults aged 18-35 years, the authors observed a bone-free lean mass gain after 8 weeks of supplementation with 20g/day of bovine colostrum.

2.5 Use of bovine colostrum in producing dairy products

In recent years, some studies have aimed at producing dairy foods with added bovine colostrum for human consumption, as can be seen in Table 3.

Yogurts with different colostrum additions were studied by Ahmadi et al. (2011), Ayar et al. (2016) and Abdel-Ghany & Zaki (2018), the authors observed that the addition of bovine colostrum in yogurt production showed good sensory acceptance.

A similar fact was observed by Saalfeld et al. (2012) with the production of milk drinks and butter with the addition of bovine colostrum silage. Other products with added colostrum that showed good sensory acceptance were reported in a study by Mouton & Aryana (2015) with ice cream developed with bovine colostrum added, and in a study conducted by Nazir et al. (2018) with the production of fermented milk with different bovine colostrum percentages.

Other studies which also aimed at evaluating bovine colostrum in producing food for human consumption were developed by Poonia & Dabur (2012), who produced a traditional Indian dessert called Khess; and also by Anamika Das & Seth (2017) who elaborated curds with colostrum addition.

From a technological point of view, lactic acid bacteria are one of the most interesting groups of bacteria and they are widely used as starter cultures in different fermentation processes (Ruiz et al., 2016). Functional properties and safety assessment of lactic acid bacteria isolated from goat colostrum for application in food fermentations was evaluate in order to establish their industrial value. The data obtained in this study demonstrate that the behavior of isolates varied with the properties assayed, and while some of them highlighted by their technological properties, other as Lac. garvieae P27M15 was the best as probiotic because of its higher resistance to low pH and to the bile salts. Therefore, it can be concluded that some isolates found have functional propertie and safety to be considered potential candidates for practical application as starters/adjunct cultures in food fermentations (Ruiz et al., 2016).

3 Final considerations

The use of bovine colostrum for human consumption has been explored for thousands of years in India, but its use as a dietary supplement is recent. Regular consumption may favor benefits such as osteoporosis prevention, reducing symptoms of arthritis and intestinal permeability, improvements in the immune system, and fighting cancer cells, among others.

Although the consumption of bovine colostrum by humans is not traditional in Brazil, some research has been conducted with the interest of evaluating its use in developing food products.

References

Abdel-Ghany, A. S., & Zaki, D. A. (2018). Production of novel functional yoghurt fortified with bovine colostrum and date syrup for children. *Alexandria Science Exchange Journal*, 39(10), 651-662. http://dx.doi.org/10.21608/asejaiqjsae.2018.20475.

Ahmadi, M., Velciov, A. B., Scurtu, M., Ahmadi, T., & Olariu, L. (2011). Benefits of bovine colostrum in nutraceutical products. *Journal of Agroalimentary Processes and Technologies*, 17(1), 42-45.

Anamika Das, D., & Seth, R. (2017). Studies on quality attributes of skimmed colostrum poder. *International Journal of Chemical Studies*, 3(5), 17-20.

Antonio, J., Sanders, M. S., & Van Gammeren, D. (2001). The effects of bovine colostrum supplementation on body composition and exercise performance in active men and women. *Nutrition*, 17(3), 243-247. http://dx.doi.org/10.1016/S0899-9007(00)00552-9. PMid:11312068.

Appukutty, M., Radhakrishnan, A. K., Ramasamy, K., Ramasamy, R., Abdul Majeed, A. B., Noor, M. I., Safii, N. S., Koon, P. B., Chinna, K., & Haleagrahara, N. (2012). Colostrum supplementation protects against exercise: induced oxidative stress in skeletal muscle in mice. *BMC Research Notes*, 5(1), 649-657. http://dx.doi.org/10.1186/1756-0500-5-649. PMid:23173926.

Ayar, A., Siçrama, H., & Çetin, I. (2016). The effect of bovine colostrum on the lactic flora of yogurt and kefir. *JSM Biotechnology & Biomedical Engineering*, 4(3), 1063.

Bagwe, S., Tharappel, L. J., Kaur, G., & Buttar, H. S. (2015). Bovine colostrum: an emerging nutraceutical. *Journal of Complementary & Integrative Medicine*, 12(3), 175-185. http://dx.doi.org/10.1515/jcim-2014-0039. PMid:25781716.

Barreto, I. M. L. G., Rangel, A. H. N., Urbano, S. A., Bezerra, J. S., & Oliveira, C. A. A. (2019). Equine milk and its potential use in the human diet. *Food Science and Technology*, 39(Suppl.), 1-7. http://dx.doi.org/10.1590/fst.11218.

Bodammer, P., Maletzki, C., Waitz, G., & Emmrich, J. (2011). Prophylactic application of bovine colostrum ameliorates murine colitis via induction of immunoregulatory cells. *The Journal of Nutrition*, 141(6), 1056-1061. http://dx.doi.org/10.3945/jn.110.128702. PMid:21525246.

Brasil, Ministério da Agricultura, Pecuária e Abastecimento – MAPA. (2017, March 29). Regulamenta a Lei nº 1.283, de 18 de dezembro de 1950, e a Lei nº 7.889, de 23 de novembro de 1989, que dispõem sobre a inspeção industrial e sanitária de produtos de origem animal-RIISPOA (Decreto nº 9.013, de 29 de março de 2017). *Diário Oficial [da] República Federativa do Brasil*, seção 1, p. 3.

Buttar, H. S., Bagwe, S. M., Bhullar, S. K., & Kaur, G. (2017). Health benefits of bovine colostrum in children and adults. In R. R. Watson, R. J. Collier & V. R. Preedy (Eds.), *Dairy in human health and disease across the lifespan* (pp. 3-20). London: Academic Press. http://dx.doi.org/10.1016/B978-0-12-809868-4.00001-7.

Ceniti, C., Froiio, F., Britti, D., Paolino, D., & Costanzo, N. (2019). Rheological characteristics of bovine colostrum and their correlation with immunoglobulin G. *International Journal of Dairy Technology*, 72(3), 345-349. http://dx.doi.org/10.1111/1471-0307.12593.

Contarini, G., Povolo, M., Pelizzola, V., Monti, L., Bruni, A., Passolungo, L., Abeni, F., & Degano, L. (2014). Bovine colostrum: changes in lipid constituents in the first 5 days after parturition. *Journal of Dairy Science*, 97(8), 5065-5072. http://dx.doi.org/10.3168/jds.2013-7517. PMid:24931528.

Conte, F., & Scarantino, S. (2013). A study on the quality of bovine colostrum: physical, chemical and safety assessment. *International Food Research Journal*, 20(2), 925-931.

Czerniewicz, M., Kielczewska, K., & Kruk, A. (2006). Comparison of some physicochemical properties of milk from Holstein-Friesian and Jersey cows. *Polish Journal of Food and Nutrition Sciences*, 15(56), 61-64.

Davison, G. (2012). Bovine colostrum and immune function after exercise. *Acute Topics in Sport Nutrition*, 59(1), 62-69. http://dx.doi.org/10.1159/000341966. PMid:23075556.

Davison, G., & Diment, B. C. (2010). Bovine colostrum supplementation attenuates the decrease of salivar lysozyme and enhances the recovery of neutrophil function afterprolonged exercise. *British Journal of Nutrition*, 103(10), 1425-1432. http://dx.doi.org/10.1017/S0007114509993503. PMid:20030905.

Du, M., Xu, W., Yi, H., Han, X., Wang, C., & Zhang, L. (2011). Protective effects of bovine colostrum acid proteins on bone loss of ovariectomized rats and the ingredients identification. *Molecular Nutrition & Food Research*, 55(2), 220-228. http://dx.doi.org/10.1002/mnfr.200900593. PMid:20669243.

Duff, W. R., Chilibeck, P. D., Rooke, J. J., Kaviani, M., Krentz, J. R., & Haines, D. M. (2014). The effect of bovine colostrum supplementation in older adults during resistance training. *International Journal of Sport Nutrition and Exercise Metabolism*, 24(3), 276-285. http://dx.doi.org/10.1123/ijsnem.2013-0182. PMid:24281841.

Eliassen, L. T., Berge, G., Sveinbjørnsson, B., Svendsen, J. S., Vorland, L. H., & Rekdal, Ø. (2002). Evidence for direct antitumor mechanism of action by bovine lactoferricin. *Anticancer Research*, 22(5), 2703-2710. PMid:12529985.

Gapper, L. W., Copestake, D. E., Otter, D. E., & Indyk, H. E. (2007). Analysis of bovine immunoglobulin G in milk, colostrum and dietary supplements: a review. *Analytical and Bioanalytical Chemistry*, 389(1), 93-109. http://dx.doi.org/10.1007/s00216-007-1391-z. PMid:17579844.

Godhia, M., & Patel, N. (2013). Colostrum: its composition, benefits as a nutraceutical: a review. *Current Research Iin Nutrition and Food Science Journal*, 1(1), 37-47. http://dx.doi.org/10.12944/CRNFSJ.1.1.04.

Gosch, T., Apprich, S., Kneifel, W., & Novalin, S. (2013). Improved isolation of bioactive components of bovine colostrum using cross-flow microfiltration. *International Journal of Dairy Technology*, 66(2), 175-181. http://dx.doi.org/10.1111/1471-0307.12027.

Gregory, S. K. (2003). Bovine colostrum: a review of clinical uses. *Alternative Medicine Review*, 8(4), 378-394.

Hałasa, M., Maciejewska, D., Baśkiewicz-Hałasa, M., Machaliński, B., Safranow, K., & Stachowska, E. (2017). Oral supplementation with bovine colostrum decreases intestinal permeability and stool concentrations of zonulin in athletes. *Nutrients*, 9(4), 370. http://dx.doi.org/10.3390/nu9040370. PMid:28397754.

Hung, L. H., Wu, C. H., Lin, B. F., & Hwang, L. S. (2018). Hyperimmune colostrum alleviates rheumatoid arthritis in a collagen-induced arthritis murine model. *Journal of Dairy Science*, 101(5), 3778-3787. http://dx.doi.org/10.3168/jds.2017-13572. PMid:29454690.

Jenny, M., Pedersen, N. R., Hidayat, B. J., Schennach, H., & Fuchs, D. (2010). Bovine colostrum modulates immune activation cascades in human peripheral blood mononuclear cells *in vitro*. *The New Microbiologica*, 33(2), 129-135. PMid:20518274.

Jones, A. W., March, D. S., Curtis, F., & Bridle, C. (2016). Bovine colostrum supplementation and upper respiratory symptoms during exercise training: a systematic review and meta-analysis of randomised controlled trials. *BMC Sports Science, Medicine and Rehabilitation*, 8(1), 21. http://dx.doi.org/10.1186/s13102-016-0047-8. PMid:27462401.

Kabała-Dzik, A., Rzepecka-Stojko, A., Kubina, R., Jastrzębska-Stojko, Ż., Stojko, R., Wojtyczka, R. D., & Stojko, J. (2017). Comparison of two components of propolis: caffeic ccid (CA) and caffeic acid phenethyl ester (CAPE) induce apoptosis and aell cycle arrest of breast cancer cells MDA-MB-231. *Molecules*, 22(9), 1554. http://dx.doi.org/10.3390/molecules22091554. PMid:28926932.

Kamel, N. N., Hafez, Y. M., El-Kholy, A. F., Maareck, Y. A., & Abou Ward, G. A. (2015). Periparturient changes in mammary gland secretions in multiparous buffalo cows (*Bubalus bubalis*). *Advances in Environmental Biology*, 9(27), 12-20.

Manzoni, P. (2016). Clinical benefits of lactoferrin for infants and children. *The Journal of Pediatrics*, 173(Suppl.), 43-52. http://dx.doi.org/10.1016/j.jpeds.2016.02.075. PMid:27234411.

March, D. S., Jones, A. W., Thatcher, R., & Davison, G. (2019). The effect of bovine colostrum supplementation on intestinal injury and circulating intestinal bacterial DNA following exercise in the heat. *European Journal of Nutrition*, 58(4), 1441-1451. http://dx.doi.org/10.1007/s00394-018-1670-9. PMid:29574607.

Marnila, P., & Korhonen, H. (2011). Colostrum. In J. W. Fuquay, P. F. Fox & P. L. H. McSweeney (Eds.), *Encyclopedia of dairy sciences* (2nd ed., pp. 591-597). San Diego: Academic Press. http://dx.doi.org/10.1016/B978-0-12-374407-4.00322-8.

Mašek, T., Krstulovic, L., Brozic, D., Vranic, M., Mauric, M., Bajic, M., & Starcevic, K. (2014). Cow colostrum and early milk enriched with eicosapentaenoic and docosahexaenoic fatty acid. *European Food Research and Technology*, 238(4), 635-640. http://dx.doi.org/10.1007/s00217-013-2144-1.

McGrath, B. A., Fox, P. F., Mcsweeney, P. L. H., & Kelly, A. L. (2016). Composition and properties of bovine colostrum: a review. *Dairy Science & Technology*, 96(2), 133-158. http://dx.doi.org/10.1007/s13594-015-0258-x.

Menchetti, L., Traina, G., Tomasello, G., Casagrande-Proietti, P., Leonardi, L., Barbato, O., & Brecchia, G. (2016). Potential benefits of colostrum in gastrointestinal diseases. *Frontiers in Bioscience*, 8(1), 331-351. PMid:27100711.

Mouton, E., & Aryana, K. J. (2015). Influence of colostrum on the characteristics of ice cream. *Food and Nutrition Sciences*, 6(5), 480-484. http://dx.doi.org/10.4236/fns.2015.65049.

Nazir, T., Pal, M. A., & Manzoor, A. (2018). Effect of admixing varying levels of whole milk to the colostrum on the sensory quality of fermented colostrum product. *International Journal of Advanced Research in Science, Engineering and Technology*, 7(4), 156-161.

Nikolic, I., Stojanovic, I., Vujicic, M., Fagone, P., Mangano, K., Stosic-Grujicic, S., Nicoletti, F., & Saksida, T. (2017). Standardized bovine colostrum derivative impedes development of type 1 diabetes in rodents. *Immunobiology*, 222(2), 272-279. http://dx.doi.org/10.1016/j.imbio.2016.09.013. PMid:27693017.

Pakkanen, R., & Aalto, J. (1997). Growth factors and antimicrobial factors of bovine colostrum. *International Dairy Journal*, 7(5), 285-297. http://dx.doi.org/10.1016/S0958-6946(97)00022-8.

Patıroğlu, T., & Kondolot, M. (2013). The effect of bovine colostrum on viral upper respiratory tract infections in children with immunoglobulin a deficiency. *The Clinical Respiratory Journal*, 7(1), 21-26. http://dx.doi.org/10.1111/j.1752-699X.2011.00268.x. PMid:21801330.

Poonia, A., & Dabur, R. S. (2012). Physico-chemical and sensory properties of khees obtained from buffalo and cow colostrum. *Journal of Dairying, Foods & Home Sciences*, 31(4), 256-258.

Rainard, P., & Riollet, C. (2006). Innate immunity of the bovine mammary gland. *Veterinary Research*, 37(3), 369-400. http://dx.doi.org/10.1051/vetres:2006007. PMid:16611554.

Rathe, M., Müller, K., Sangild, P. T., & Husby, S. (2014). Clinical applications of bovine colostrum therapy: a systematic review. *Nutrition Reviews*, 72(4), 237-254. http://dx.doi.org/10.1111/nure.12089. PMid:24571383.

Ribeiro, K. D. S., Lima, M. S. R., Medeiros, J. F. P., Rebouças, A. S., Dantas, R. C. S., Bezerra, D. S., Osório, M. M., & Dimenstein, R. (2016). Association between maternal vitamin E status and alpha-tocopherol levels in the newborn and colostrum. *Maternal and Child Nutrition*, 12(4), 1-7. PMid:26924492.

Ruiz, P., Barragán, I., Seseña, S., & Palop, M. L. (2016). Functional properties and safety assessment of lactic acid bacteria isolated from goat colostrum for application in food fermentations. *International Journal of Dairy Technology*, 69(4), 559-568. http://dx.doi.org/10.1111/1471-0307.12293.

Saad, K., Abo-Elela, M. G. M., El-Baseer, K. A. A., Ahmed, A. E., Ahmad, F.-A., Tawfeek, M. S. K., El-Houfey, A. A., Aboul_Khair, M. D., Abdel-Salam, A. M., Abo-elgheit, A., Qubaisy, H., Ali, A. M., & Abdel-Mawgoud, E. (2016). Effects of bovine colostrum on recurrent respiratory tract infections and diarrhea in children. *Medicine*, 95(37), 175-185. http://dx.doi.org/10.1097/MD.0000000000004560. PMid:27631207.

Saalfeld, M. H. (2015). *Relatório técnico para MAPA e ANVISA sobre uso de colostro e derivados de colostro bovino para alimentação humana*. Brasília: Fundação Banco do Brasil. Retrieved from http://tecnologiasocial.fbb.org.br/lumis/portal/file/fileDownload.jsp?fileId=2C908A915BEDB4C3015C0EA611BE478A&inline=1

Saalfeld, M. H., Pereira, D. I. B., Silveira, K. R. K., Diniz, G. L., Kringel, D. H., Alves, M. I., Gularte, M. A., & Leite, F. P. L. (2012). Colostro: a redescoberta de um alimento saudável, nutritivo e com potencial probiótico. *Agroecologia e Desenvolvimento Rural Sustentável*, 5(2), 18-24.

Satyaraj, E., Reynolds, A., Pelker, R., Labuda, J., Zhang, P., & Sun, P. (2013). Supplementation of diets with bovine colostrum influences immune function in dogs. *British Journal of Nutrition*, 110(12), 2216-2221. http://dx.doi.org/10.1017/S000711451300175X. PMid:23773360.

Shing, C. M., Hunter, D. C., & Stevenson, L. M. (2009). Bovine colostrum supplementation and exercise performance. *Sports Medicine*, 39(12), 1033-1054. http://dx.doi.org/10.2165/11317860-000000000-00000. PMid:19902984.

Steele, J., Sponseller, J., Schmidt, D., Cohen, O., & Tzipori, S. (2013). Hyperimmune bovine colostrum for treatment of GI infections. *Human Vaccines & Immunotherapeutics*, 9(7), 1565-1568. http://dx.doi.org/10.4161/hv.24078. PMid:23435084.

Struff, W. G., & Sprotte, G. (2007). Bovine colostrum as a biologic in clinical medicine: a review. Part I: biotechnological standards, pharmacodynamic and pharmacokinetic characteristics and principles of treatment. *International Journal of Clinical Pharmacology and Therapeutics*, 45(4), 193-202. http://dx.doi.org/10.5414/CPP45193. PMid:17474538.

Sty, A. C., Sangild, P. T., Skovgaard, K., Thymann, T., Bjerre, M., Chatterton, D. E., Purup, S., Boye, M., & Heegaard, P. M. (2016). Spray dried, pasteurised bovine colostrum protects against gut dysfunction and inflammation in preterm pigs. *Journal of Pediatric Gastroenterology and Nutrition*, 63(2), 280-287. http://dx.doi.org/10.1097/MPG.0000000000001056. PMid:26756878.

Wakabayashi, H., Oda, H., Yamauchi, K., & Abe, F. (2014). Lactoferrin for prevention of common viral infections. *Journal of Infection and Chemotherapy*, 20(11), 666-671. http://dx.doi.org/10.1016/j.jiac.2014.08.003. PMid:25182867.

Wang, W., Uzzau, S., Goldblum, S. E., & Fasano, A. (2000). Human zonulin, a potential modulator of intestinal tight junctions. *Journal of Cell Science*, 113(24), 4435-4440. PMid:11082037.

Wong, E. E., Mallet, J. F., Duarte, J., Matar, C., & Ritz, B. W. (2014). Ovine colostrum enhances natural killer cell activity and immune response in a mouse model of influenza infection and mediates intestinal immunity through toll-like receptors 2 and 4. *Nutrition Research*, 34(4), 318-325. http://dx.doi.org/10.1016/j.nutres.2014.02.007. PMid:24774068.

Woof, J. M., & Kerr, M. A. (2006). The function of immunoglobulin A in immunity. *The Journal of Pathology*, 208(2), 270-282. http://dx.doi.org/10.1002/path.1877. PMid:16362985.

Yurchenko, S., Sats, A., Poikalainen, V., & Karus, A. (2016). Method for determination of fatty acids in bovine colostrum using GC-FID. *Food Chemistry*, 212(1), 117-122. http://dx.doi.org/10.1016/j.foodchem.2016.05.103. PMid:27374514.

Zhang, H. (2019). Amelioration of decline in immune function in athletes after high-intensity training by bovine colostrum. *Current Topics in Nutraceutical Research*, 17(2), 219-222.

Zou, X., Guo, Z., Jin, Q., Huang, J., Cheong, L., Xu, X., & Wang, X. (2015). Composition and microstructure of colostrum and mature bovine milk fat globule membrane. *Food Chemistry*, 185(15), 362-370. http://dx.doi.org/10.1016/j.foodchem.2015.03.145. PMid:25952880.