Article

Fermentation Ability of Bovine Colostrum by Different Probiotic Strains

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Abstract: Over the past decade, the use of bovine colostrum and its bioactive components as the basis of functional food and dietary supplements for humans has substantially increased. However, for developing new products enriched with probiotics and bovine colostrum, the influence of colostrum composition on the growth promotion of bacteria still needs to be tested. Therefore, we decided to study the influence of bovine colostrum chemical and mineral composition as well as the content of bioactive compounds (immunoglobulins, lactoferrin, lactoperoxidase) on the growth of ten selected strains from genera Lactobacillus, Lacticaseibacillus, Bifidobacterium, and Enterococcus. After 24 h of fermentation, the growth was assessed based on lactic and acetic acids production evaluated using isotachophoresis, bacterial counts determined by the agar plate method, and change of pH. The production of acids and bacterial counts were significantly (P<0.05) different between selected genera. The change of bacterial counts was correlated with pH, but the correlation between growth and bovine colostrum composition was not proven. The highest growth and production of lactic acid was observed after the fermentation of bovine colostrum by the strains Enterococcus faecium CCDM 922A and CCDM 945.

Keywords: bovine colostrum; probiotics; functional foods; minerals; lactic acid bacteria

1. Introduction

Colostrum is the first milk with a unique nutritive profile produced by mammals immediately after birth [1,2]. The specific composition and physical characteristics of colostrum of an animal are influenced by breed, type of feeding, health status, and time post-parturition or other factors [3]. In comparison with mature milk, colostrum contains more total solids, proteins, vitamins, and mineral substances [4]. From bioactive components present in bovine colostrum, immunoglobulins (IgG1), growth factors (insulin-like growth factor-1, transforming growth factor beta-2), growth hormone and antimicrobial substances, such as lactoferrin, lysozyme and lactoperoxidase are of importance. They participate in moderating and maintaining a robust immunoprotective environment [5–8]. Lactoferrin is an iron-binding glycoprotein secreted by epithelial cells into body fluids (tears, saliva, blood, colostrum etc.) or by neutrophils at inflammatory disease. [9] Antioxidant, antibacterial (against E. coli, Helicobacter pylori or Candida albicans), antiviral (against HSV-1 or HIV-1) abilities and immunomodulatory effects of lactoferrin were demonstrated in numbers in vivo studies [6,9,10]. Lactoferrin was also a first bioactive...
component of milk used as supplement in infant formula, cosmetics, and oral care products [7]. Other important components are lactoperoxidase and the lytic enzyme lysozyme, used for food preservation. Bovine colostrum, due to content of these antimicrobial components, has been tested for the treatment and prevention of various infectious diseases caused by bacteria, viruses, and protozoal pathogens [11,12]. The level of lysozyme in milk differs among species and within the same species, being influenced by the nutrition, parturition, breeds, and other factors. Nevertheless, milks are possible to divide into two groups based on lysozyme content. The first group of milks contains a high level of lysozyme (200–1330 mg/L); to this group belong human, equine, and canine milks. Bovine, ovine, and goat milks belong to the second group containing 3000–6000 times lower concentration of lysozyme than in the first group [13]. Oligosaccharides with prebiotic effects are naturally present in colostrum and can improve the growth of probiotic microorganisms such as lactobacilli and bifidobacteria [3,14]. Probiotics are defined by the FAO/WHO [15] as “live microorganisms which, when administrated in adequate amounts confers a healthy benefit to the host”. The most important probiotic microorganisms are lactobacilli (e.g., Lactobacillus acidophilus, L. bulgaricus, Lactcaseibacillus casei, Lactcaseibacillus paracasei), bifidobacteria (e.g., Bifidobacterium bifidum, B. longum, B. animalis, B. lactis) which are widely applied to a variety of functional foods and food supplements for humans and animals [16]. An increase in studies investigating the positive effects of probiotics has been seen in last twenty years. Some of the reported beneficial effects of probiotics are associated with immune response modulation and cholesterol lowering [17,18]. Other benefits include the prevention and treatment of gastrointestinal diseases and allergies such as colitis, colon cancer, and irritable bowel syndrome [19]. The combination of health benefits of probiotics and colostrum can help to supply a market of food supplements and functional food with new products.

Only a few research works have been published about the fermentation of bovine colostrum by lactic acid bacteria in order to preserve colostrum or its enrichment with other beneficial components such as probiotics, with the aim to develop new functional foods for humans and animals [20–23]. The fermentation of bovine colostrum by suitable strains might be helpful in the prevention of diarrhea in calves or to increase colostrum quality by inhibition of pathogenic and spoilage microbiota [24]. Therefore, the aim of our study was to evaluate the influence of ten probiotic strains and composition of bovine colostrum (fat, proteins, minerals, bioactive compounds) for the fermentation of colostrum in in vitro conditions.

2. Materials and Methods

2.1. Colostrum

Ten samples of bovine colostrum (C1–C10) were collected from first milking of Czech pied cattle cows within 2 h post-partum, (the farm Kojcice, Czech Republic). The samples of colostrum were immediately frozen after milking and stored at −20 °C.

2.2. Determination of Gross Composition and Bioactive Compounds

The gross composition of bovine colostrum samples was analyzed as follows. The nitrogen content was analyzed by the Kjeldahl method using Kjeltec 8420 (Foss, Hillerød, Denmark) and converted to protein content using factor of 6.38. Fat content was determined using the butyrometric method and dry matter by gravimetric analysis. pH values were measured by the device pH/cond 340i (WTW, Weilheim, Germany). The levels of immunoglobulin-G (IgG) and lactoferrin were determined using radial immunodiffusion by commercial kit BINDARIDTM (The Binding Site, Birmingham, UK) and kit BOV Lfr Test (IDBiotech, Issoire, France). The concentration of lactoperoxidase was measured according ISO/TS 17193:2011. The concentration of lysozyme was analyzed using the spectrophotometric method of enzymatic activity of lysozyme EC 3.2.1.17 (Sigma-Aldrich, Buchs, Switzerland) with some modifications according Castillo et al. [25]. Lactose was determined using enzymatic method by commercial kit MEGAZYME (Megazyme, Bray, Ireland).
2.3. Mineral Analysis

For the determination of Ca, Mg, Zn, Na, K, and Cu in bovine colostrum, aliquots of colostrum (20 g) were dried and mineralized by dry ashing [26] in triplicate repetitions. Ca, Mg, Zn, K, and Na were determined by flame atomic absorption spectrometry (FAAS) in a Varian SpectrAA 300 device (Agilent, Santa Clara, CA, USA) in flame acetylene—air at wavelengths of 422.7 nm (Ca), 285.2 nm (Mg), 213.9 nm (Zn), 766.5 nm (K), and 589 nm (Na), respectively. In the Ca and Mg determination, 1.0% solution of lanthanum nitrate was added as a releasing agent. Cu was determined in a Varian SpectrAA 400 atomic absorption spectrometer (Agilent, Santa Clara, CA, USA) finished with GTA -96 electrothermal atomizer at the wavelength 423.8 nm. Cu content was evaluated from the calibration curve based on peak areas.

2.4. Growth of Probiotic and Potential Probiotic Strains in Bovine Colostrum

Tested strains were obtained from the Culture Collection of Dairy Microorganisms Laktoflora® from the Czech University of Life Sciences (Czech Republic) and biopsy samples, as shown in Table 1. Probiotic strain Bifidobacterium animalis subsp. lactis Bb12 is commercial culture from Chr. Hansen (Hørsholm, Denmark). Sterile 8 mL aliquots of De Man–Rogosa–Sharpe (MRS) broth (MERCK, Darmstadt, Germany) for lactobacilli (pH 5.7) and bifidobacteria (pH 6.2) were inoculated with 1.0% (v/v) of each strain and cultivated in anaerobic conditions at 37 °C for 18 h. Enterococci strains were grown in M17 broth (MERCK, Darmstadt, Germany) at 37 °C in aerobic conditions.

Table 1. Tested microorganisms.

| Strain   | Species                  | Origin         | Growth Condition                           |
|----------|--------------------------|----------------|--------------------------------------------|
| * CCDM 229 | B. animalis ssp. animalis | original culture |                                             |
| * CCDM 562 | B. breve                     | GIT of child | MRS broth/agar 6.2 + L-cysteine hydrochloride; anaerobic, 37 °C, 72 h |
| ** AVNB3-P1 | B. adolescentis            | GIT of child |                                             |
| *** JOV   | B. bifidum                 | infant faeces |                                             |
| *** KJM   | B. bifidum                 | infant faeces |                                             |
| Bb12     | B. animalis ssp. lactis    | original culture |                                             |
| * CCDM 150 | Lactisaelbacillus rhamnosus | curd         | MRS broth/agar 5.7; anaerobic 37 °C, 72 h |
| * CCDM 66  | L. delbruecki ssp. bulgaricus | yogurt      |                                             |
| * CCDM 151 | L. acidophilus              | tabl. Biolacta |                                             |
| *** RL 25 | Linosilactobacillus fermentum | human faeces |                                             |
| ** DM1TA6-P | Lactisaelbacillus paracasei | GIT of child |                                             |
| * CCDM 945 | Enterococcus faecium       | original culture | M 17 broth/agar; aerobic 37 °C, 72 h |
| * CCDM 922A | Enterococcus faecium       | isolated      |                                             |

* Culture Collection of Dairy Microorganisms Laktoflora, Czech Republic; ** isolate obtained from the biopsy sample of child, *** Czech University of Life Sciences, Prague Czech Republic; GIT—Gastrointestinal tract.

After cultivation, bacterial cells were harvested by centrifugation (6000×g, 7 min.), washed with sterile saline solution, and then resuspended in saline solution to a final concentration of 10^3–10^4 CFU/mL. Before growth testing, colostrum samples were pasteurized at 62.5 °C for 30 min, then cooled at 37 °C and inoculated with 1.0% (v/v) of bacterial suspension. Inoculated samples of colostrum were cultivated in anaerobic jars at 37 °C for 24 h. The counts of tested strains were determined using 10-fold serial dilution at 0 and 24 h and cultivated onto MRS agar (MERCK, Darmstadt, Germany)/M17 agar, as shown in Table 1. The pH and concentration of lactic and acetic acids were also measured. The concentrations of lactic and acetic acids were determined by the isotachophoretic method (ITP) using IONOSEP 2003 (RECMAN, Ostrava, Czech Republic). A mixture of 10 mmol/L HCl, 22 mmol/L 6-aminocaproic acid and 0.1% hydroxyethylcellulose was used as a leading electrolyte and 10 mmol/L caproic acid as a terminating electrolyte. Samples of colostrum were diluted 50-fold with demineralized water. The conditions of analysis were selected according to the manufacturer’s instructions (RECMAN, Ostrava, Czech Republic). The evaluation was performed using calibration curves and levels of tested acid were expressed in mg per 100 mL of samples.
2.5. Statistical Analysis

All statistical evaluations were performed using Microsoft Office Excel 2019 and Statistica 13.1CZ statistical software (StatSoft, Tulsa, USA). Normality of data was checked using Shapiro–Wilk’s test. One-way analysis of variance (ANOVA) at a significance level of \( \alpha = 0.05 \) followed by the Tukey’s test were applied to the comparison of pH and the concentration of lactic and acetic acids; for the growth, Kruskall–Wallis’s test followed by the Dunn’s test was used. Correlations were evaluated by testing significance of Pearson correlation coefficient (chemical and mineral composition, bioactive compounds, pH) and Spearman correlation coefficient (growth). Results were expressed as mean (standard derivation).

3. Results and Discussion

Over the past decade, the use of bovine colostrum and its bioactive components as basis of functional food and dietary supplements for humans has substantially increased [4,27]. Microfiltration or heat treatment using low temperature for prolonged time can be used for the elimination of undesirable microorganisms. These processes are the gentlest for preserving bioactive compounds in bovine colostrum [28]. Heat treatment at 62.5 ºC for 30 min was used in this study. High temperature for short time periods (72 ºC, 15 s) caused a decrease in Ig activity by 10–30% and using UHT treatment (138 ºC, 4 s) or spray drying destroyed most of Ig activity [5,29]. The basic chemical and mineral composition in tested samples of bovine colostrum from Czech pied cattle is presented in Tables 2 and 3. The pH of colostrum is generally lower than that of mature milk and increases after post-partum [30]. The pH values of tested samples were on average 6.43 ± 0.20 which was similar as determined in a study of Elfstrand et al. [5]. Relatively, few studies have been reported the information about the concentration of minerals in colostrum and milk during the early post-partum period. Kehoe et al. [31] observed the chemical and mineral composition of bovine colostrum from Pennsylvania Dairy farms. The average levels of copper and zinc in colostrum were 1.7- and 10.9-fold higher than in milk. A similar trend was observed for the concentrations of copper and iron in colostrum over the first 108 h post-partum in the study of Jeong et al. [32]. The concentrations of magnesium (1.36 ± 0.30 g/kg), potassium (6.47 ± 1.85 g/kg), and zinc (95.87 ± 22.73 mg/kg) were higher than those determined by Kehoe et al. [31]. Different levels of minerals, proteins, fats, and bioactive compounds in colostrum may be related to individuality, breed, parity, pre-partum nutrition, length of the dry period of cows, and time post-partum and others [29,33]. The higher concentration of protein in colostrum in comparison with mature milk is associated with the high concentration of immunoglobulins [34]. The average concentration of IgG1 was 52.54 ± 5.16 mg/mL (Table 4) in the presented study, but Silva et al. [35] described a lower value of IgG1 35.00 mg/mL. The differences between values could be caused by gradual decreasing concentration of immunoglobulins during lactation. Our samples were collected from first milking within 2 h post-partum. Colostrum also contains a significant amount of lactoferrin, lactoperoxidase, and lysozyme, which have antimicrobial and antiviral properties, and help protect the neonate against infections [36].
Table 2. Chemical composition of bovine colostrum samples (C1–C10).

| Bovine Colostrum | pH     | Fat (%) | TS (%) | Protein (%) | Lactose (%) |
|------------------|--------|---------|--------|-------------|-------------|
| C1               | 6.44 ± 0.09 | 12.18 ± 0.06 | 20.22 ± 0.02 | 15.22 ± 0.01 | 2.14 ± 0.00 |
| C2               | 6.50 ± 0.13 | 7.03 ± 0.02 | 26.04 ± 0.04 | 14.97 ± 0.02 | 2.29 ± 0.04 |
| C3               | 6.65 ± 0.15 | 11.00 ± 0.09 | 33.88 ± 0.01 | 21.30 ± 0.01 | 2.07 ± 0.07 |
| C4               | 6.86 ± 0.06 | 5.10 ± 0.01 | 15.48 ± 0.02 | 4.91 ± 0.01 | 2.01 ± 0.00 |
| C5               | 6.45 ± 0.04 | 7.54 ± 0.02 | 26.55 ± 0.04 | 15.38 ± 0.02 | 2.83 ± 0.00 |
| C6               | 6.45 ± 0.02 | 7.44 ± 0.01 | 16.40 ± 0.02 | 18.29 ± 0.01 | 2.68 ± 0.00 |
| C7               | 6.12 ± 0.01 | 6.00 ± 0.01 | 21.23 ± 0.01 | 11.83 ± 0.00 | 2.55 ± 0.01 |
| C8               | 6.34 ± 0.05 | 5.40 ± 0.05 | 26.07 ± 0.01 | 15.98 ± 0.04 | 3.55 ± 0.00 |
| C9               | 6.22 ± 0.01 | 6.70 ± 0.09 | 23.89 ± 0.04 | 12.54 ± 0.01 | 2.26 ± 0.00 |
| C10              | 6.25 ± 0.05 | 4.30 ± 0.02 | 26.74 ± 0.01 | 18.29 ± 0.03 | 4.05 ± 0.01 |

TS—total solids; C1–10—Samples of bovine colostrum; Value mean ± SD, n = 3.

Table 3. Mineral composition of bovine colostrum samples (C1–C10).

| Samples of Colostrum | Ca (g/kg) | Mg (g/kg) | Zn (mg/kg) | K (g/kg) | Na (mg/kg) | Cu (ug/g) |
|----------------------|-----------|-----------|------------|----------|------------|-----------|
| C1                   | 3.06 ± 0.02 | 1.14 ± 0.02 | 76.08 ± 0.78 | 3.70 ± 0.07 | 956.38 ± 80.36 | 409.19 ± 46.41 |
| C2                   | 3.10 ± 0.26 | 1.62 ± 0.11 | 98.93 ± 6.75 | 7.56 ± 0.78 | 941.43 ± 144.90 | 460.40 ± 47.21 |
| C3                   | 3.06 ± 0.04 | 1.79 ± 0.09 | 81.61 ± 2.61 | 8.55 ± 0.19 | 1043.83 ± 48.74 | 701.42 ± 13.93 |
| C4                   | 3.64 ± 0.59 | 1.37 ± 0.27 | 124.27 ± 15.13 | 9.34 ± 0.62 | 497.04 ± 86.93 | 749.35 ± 138.98 |
| C5                   | 2.35 ± 0.35 | 0.86 ± 0.10 | 44.77 ± 1.59 | 5.90 ± 0.72 | 275.42 ± 76.05 | 353.50 ± 63.16 |
| C6                   | 3.51 ± 0.15 | 1.56 ± 0.05 | 99.16 ± 6.31 | 8.17 ± 0.45 | 620.39 ± 16.40 | 599.29 ± 30.20 |
| C7                   | 2.91 ± 0.09 | 1.25 ± 0.05 | 116.11 ± 4.44 | 6.52 ± 0.08 | 615.64 ± 35.72 | 501.66 ± 24.11 |
| C8                   | 2.24 ± 0.12 | 1.46 ± 0.06 | 106.60 ± 2.34 | 6.35 ± 0.06 | 568.82 ± 245.54 | 611.51 ± 26.71 |
| C9                   | 5.06 ± 0.19 | 0.88 ± 0.18 | 91.04 ± 5.35 | 4.51 ± 0.08 | 903.34 ± 50.73 | 414.66 ± 21.79 |
| C10                  | 7.19 ± 0.50 | 1.62 ± 0.11 | 120.11 ± 3.51 | 4.05 ± 0.40 | 545.37 ± 222.96 | 264.19 ± 192.70 |

C1–10—Samples of bovine colostrum; Value mean ± SD, n = 3.

Table 4. Concentration of bioactive compounds in the tested bovine colostrum samples (C1–C10).

| Bovine Colostrum | IgG1 (mg/mL) | Lactoferrin (ug/mL) | Lactoperoxidase (Units/L) | Lysozyme (Units/mL) |
|------------------|--------------|---------------------|--------------------------|---------------------|
| C1               | 52.27 ± 2.26 | 222.00 ± 7.07       | 222.00 ± 1.41            | 239.00 ± 4.24       |
| C2               | 48.33 ± 0.42 | 490.50 ± 2.83       | 490.50 ± 7.78            | 131.00 ± 5.66       |
| C3               | 59.80 ± 0.81 | 122.50 ± 7.78       | 122.50 ± 10.61           | 389.00 ± 4.24       |
| C4               | 60.23 ± 1.41 | 234.50 ± 2.83       | 234.50 ± 14.85           | 737.50 ± 12.02      |
| C5               | 53.94 ± 3.28 | 548.00 ± 7.78       | 548.00 ± 1.41            | 931.50 ± 13.44      |
| C6               | 42.84 ± 0.58 | 687.50 ± 6.36       | 687.50 ± 3.54            | 263.00 ± 2.83       |
| C7               | 54.72 ± 2.92 | 572.00 ± 24.04      | 572.00 ± 16.97           | 638.00 ± 5.66       |
| C8               | 50.52 ± 0.34 | 245.50 ± 51.62      | 245.50 ± 7.78            | 631.50 ± 3.54       |
| C9               | 52.62 ± 1.19 | 433.00 ± 7.78       | 433.00 ± 4.24            | 341.50 ± 4.95       |
| C10              | 50.17 ± 1.50 | 419.50 ± 5.66       | 419.50 ± 2.12            | 839.00 ± 4.24       |

IgG1—Immunoglobulins; Value mean ± SD, n = 3.

In this study, bovine colostrum from cows of Czech pied cattle was also tested as a growth medium for probiotic and potential probiotic microorganisms in vitro condition. The growth of strains tested was evaluated on the bases of lactic and acetic acid production, decrease in pH, and increase in bacterial counts. Average values of observed parameters after 24-h anaerobic cultivation are presented in Table 5. Bacterial counts of selected bifidobacteria and lactobacilli were significantly lower (p < 0.05) in contrast to both of the enterococcal strains (E. faecium CCDM 922A and E. faecium CCDM 945) which grew similarly in all bovine colostrum samples. The statistically lower growth of tested lactobacilli was determined in colostrum samples C1–C4 and on the contrary a higher growth was in the samples C8–10 (p < 0.05). The similar trend was also evaluated in case of tested bifidobacteria and enterococci. The lower growth of tested strains in samples C1–4 might have been caused by antimicrobial substances present in bovine colostrum, such as lactoperoxidase, lactoferrin, and lysozyme which constitute the antimicrobial system of colostrum or by different content of minerals and proteins, fat and lactose, as shown in Tables 3–5. However, the correlation between the composition of bovine colostrum and the
change bacterial counts was not proven but only the change of cell counts at most of the tested strains correlated with the change of pH. Colostrum sample C4 had the lowest concentration of proteins and the highest contents of copper (749.35 ± 138.98 µg/kg) and lysozyme 931.50 ± 13.44 units/mL, while both had proven antimicrobial properties [37,38]. Higher protein content has higher buffering capacity which may influence the production of lactic acid but the correlation between production of lactic acid and concentration was not ascertained in the present study. Rockova et al. [28] tested the growth of seven bifidobacteria in mammalian milk samples from humans, swine, cows, rabbits, and sheep. A production of lactic acid higher than 100 mg/100 mL was evaluated to have sufficient growth of bifidobacteria. In our study, tested bifidobacteria produced on average 123.02 mg/100 mL of lactic acid, which is in agreement with the findings of Rockova et al. [28]. The significantly highest production of lactic acid (160.30 ± 33.89 and 170.12 ± 41.57 mg/100 mL) was determined after the fermentation of bovine colostrum by both enterococcal strains – E. faecium CCDM 922A and E. faecium CCDM 945. You et al. [39] investigated the counts of oxygen-resistant B. bifidum in bovine colostrum after 10-h cultivation at 37 °C and the stability of IgG levels during fermentation. The average count of B. bifidum after cultivation was approximately 9.52 log CFU/mL. In another study, Saalfeld et al. [23] observed the effect of anaerobic bovine colostrum fermentation on bacteria growth inhibition. The results showed that this process was able to inhibit the growth of undesirable bacteria, such as B. abortus, E. coli, L. interrogans, M. bovis, S. enteritidis, S. typhimurium, and S. aureus, but counts of the lactic acid bacteria remained throughout the 30 days fermentation process about 107 CFU/mL. The fermentation of colostrum by lactic acid bacteria can be used as alternative methods for the preservation of colostrum with the functional benefits of probiotic bacteria. Another possibility is the isolation of new lactic acid bacteria from colostrum and their return application into colostrum [40].

### Table 5. Comparison of average values of tested parameters after 24 h of cultivation selected strains in bovine colostrum.

| Strains      | Lactic Acid (mg/100 mL) | Acetic Acid (mg/100 mL) | Bacterial Growth (CFU/mL) | pH             |
|--------------|-------------------------|-------------------------|----------------------------|----------------|
| CCDM 151     | 108.28 ± 34.39 A,B      | 12.25 ± 3.35 A          | 6.81 ± 1.60 A              | 5.55 ± 4.48 A  |
| DMI TA6-P    | 95.56 ± 32.74 A         | 13.43 ± 4.64 A          | 6.86 ± 1.39 A              | 5.61 ± 0.55 A  |
| CCDM 66      | 99.93 ± 42.39 A,B       | 12.57 ± 4.32 A          | 7.28 ± 1.02 A              | 5.58 ± 0.62 A  |
| CCDM 150     | 102.82 ± 37.35 A,B      | 12.35 ± 3.82 A          | 7.04 ± 1.57 A              | 5.57 ± 0.58 A  |
| RL25         | 112.79 ± 9.19 A,B       | 12.04 ± 2.42 A          | 7.50 ± 1.10 A              | 5.51 ± 0.49 A  |
| JKM          | 128.48 ± 44.47 A-C      | 14.04 ± 4.26 A          | 7.53 ± 0.50 A              | 5.44 ± 0.50 A  |
| JOV          | 132.17 ± 43.55 A-C      | 14.72 ± 6.24 A          | 7.77 ± 0.49 A              | 5.42 ± 0.47 A  |
| CCDM 229     | 130.54 ± 30.09 A-C      | 14.34 ± 2.87 A          | 7.52 ± 0.61 A              | 5.45 ± 0.51 A  |
| CCDM 562     | 112.81 ± 47.42 A-C      | 11.25 ± 4.29 A          | 6.78 ± 1.60 A              | 5.59 ± 0.60 A  |
| AVNB3-P1     | 123.37 ± 46.03 A-C      | 15.60 ± 4.98 A          | 7.13 ± 1.11 A              | 5.58 ± 0.58 A  |
| Bb12         | 120.71 ± 47.55 A-C      | 15.77 ± 6.06 A          | 6.76 ± 1.13 A              | 5.53 ± 0.56 A  |
| CCDM 945     | 160.30 ± 33.89 B,C      | 13.51 ± 7.10 A          | 8.41 ± 0.31 B              | 5.26 ± 0.21 A  |
| CCDM 922     | 170.12 ± 41.57 C        | 12.84 ± 4.96 A          | 8.33 ± 0.50 B              | 5.22 ± 0.16 A  |

*Values are means of triplicate measurements ± standard deviation. A-C Data in the column with different superscripts differ (p < 0.05).*

### 4. Conclusions

In conclusion, we showed that the growth of tested bifidobacteria, lactobacilli, and enterococci and the production of lactic acid by selected strains in samples of bovine colostrum were significantly (p < 0.05) different. We supposed that the chemical and mineral composition of bovine colostrum influenced the growth of the strains tested along with the presence of antimicrobial substances, but the correlations between bacterial growth and tested parameters were not ascertained. Nevertheless, we will isolate a particular fraction of bovine colostrum, such as proteins, oligosaccharides, or enzymes and will research their effect to viability or growth of selected bacteria in the further studies. These findings will be important for the development of functional food or food supplements for humans or animals.
containing bovine colostrum and probiotic microorganisms. The fermentation process by lactic acid bacteria or probiotics can be a good alternative for the conservation of colostrum.

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