BRYNDZA CHEESE OF SLOVAK ORIGIN AS POTENTIAL RESOURCES OF PROBIOTIC BACTERIA

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ABSTRACT
Bryndza cheese includes several predominant lactic acid bacteria. The aim of our study was the antagonistic effect of lactic acid bacteria supernatant isolated from ewes’ cheese bryndza against ten Gram-positive and Gram-negative bacteria. Isolated strains of bacteria were obtained from bryndza which were produced in five different regions of Slovakia. Isolated strains of lactic acid bacteria were identified with mass spectrometry MALDI-TOF MS Biotyper. A total of one hundred and thirty lactic bacteria include Enterococcus faecalis, Enterococcus faecium, Enterococcus hirae, Lactobacillus brevis, Lactobacillus harbinensis, Lactobacillus johnsonii, Lactobacillus plantarum, Lactobacillus paracasei ssp. paracasei, Lactobacillus paraplatantum, Lactobacillus suebicus, Lactococcus lactis ssp. lactis, Lactococcus lactis, and Pediococcus acidilactici were tested in this study against Gram-negative bacteria: Escherichia coli CCM 3988, Klebsiella pneumoniae CCM 2318, Salmonella enterica ssp. enterica CCM 3807, Shigella sonnei CCM 1373, Yersinia enterocolitica CCM 5671 and Gram-positive bacteria: Bacillus thuringiensis CCM 19, Enterococcus faecalis CCM 4224, Listeria monocytogenes CCM 4699, Staphylococcus aureus ssp. aureus CCM 2461, Streptococcus pneumonia CCM 4501 with agar diffusion method. Lactic acid bacteria showed activity 92% against Yersinia enterocolitica, 91% against Klebsiella pneumoniae, 88% against Enterococci coli, 84% against Listeria monocytogenes. The most effective bacteria against Gram-positive and Gram-negative bacteria tested was Lactobacillus paracasei ssp. paracasei.

Keywords: bryndza; Gram-positive and Gram-negative bacteria; lactic acid bacteria; probiotic effect; mass spectrometry

INTRODUCTION
Bryndza is a traditional Slovak natural white spreadable ripened cheese with Protected geographical indication status (Commission Regulation (EC) No. 676/2008). Bryndza is made from ewes’ milk or a mixture of ewes’ milk and cows’ milk and is a rich source of protein, vitamins, and minerals (Toth et al., 2016). Bryndza is a dairy product that naturally contains a broad spectrum of microorganisms that has crucial importance on cheese properties, flavor, and aroma. Microorganisms are present during the whole process of cheese production, they are important in coagulation and ripening (Andrade et al., 2008; Tiloca et al., 2020). Also, beneficial strains help to inhibit the growth of the pathogens and reduce the spoilage of the dairy products (Arqués et al., 2015).

In previous research Gram-positive, Gram-negative bacteria, and yeasts were found and identified in bryndza (Kačániová et al., 2019). The dominant group of bacteria in bryndza was lactic acid bacteria (LAB), mainly Lactobacillus species (Kačániová et al., 2020). Lactococcus, Pediococcus, Enterococcus, Streptococcus were abundant in bryndza from different Slovak regions also (Berta et al., 2009; Šaková et al., 2015; Sádecká et al., 2019). The probiotic properties of bacteria isolated from bryndza were observed in Lactobacillus plantarum, Enterococcus faecium, and Enterococcus faecalis strains. Researches claimed that these potentially probiotic strains can inhibit the growth of pathogenic bacteria, and some of them can survive in the acidic gastrointestinal environment, which is necessary for reaching the intestine of the host (Belicová et al., 2011; Belicová et al., 2013). Probiotic bacteria as an important part of intestinal microbiota helps regulate the immune responses, relieve the gastrointestinal tract dysfunction, alleviate the allergies, or lower cholesterol levels (Dicks and Botes, 2010; Plaza-Diaz et al., 2019). Moreover, the anticarcinogenic properties of probiotic bacteria have been described (Zhong et al., 2014).

Our study aimed to evaluate lactic acid bacteria isolated from ewes’ bryndza and select the most active probiotic bacterial strain against pathogens and opportunistic pathogens.
Staphylococcus aureus

luteus

bacteria: performed using the MALDI-TOF MS Biotyper. Subsequently, an analysis of the bacteria identification was colony of each bacterial isolate was selected for screening.

Enterococcus faecalis

Enterococcus faecium

Enterococcus hirae

Lactobacillus brevis

Lactobacillus harbinensis

Lactobacillus johnsonii

Lactobacillus plantarum

Lactobacillus paracasei ssp. paracasei

Lactobacillus paraplanterum

Lactobacillus suebicus

Lactococcus lactis ssp. lactis

Lactococcus lactis

Pediococcus acidilactici

| Species of LAB | Number of isolates |
|---------------|-------------------|
| Enterococcus faecalis | 10 |
| Enterococcus faecium | 10 |
| Enterococcus hirae | 10 |
| Lactobacillus brevis | 10 |
| Lactobacillus harbinensis | 10 |
| Lactobacillus johnsonii | 10 |
| Lactobacillus plantarum | 10 |
| Lactobacillus paracasei ssp. paracasei | 10 |
| Lactobacillus paraplanterum | 10 |
| Lactobacillus suebicus | 10 |
| Lactococcus lactis ssp. lactis | 10 |
| Lactococcus lactis | 10 |
| Pediococcus acidilactici | 10 |

**MATERIAL AND METHODOLOGY**

**Isolation of lactic acid bacteria**

A total of 130 lactic acid bacteria were isolated from Slovak ewes’ bryndza. The bryndza samples were obtained from five producers in Slovakia. Before identification, the lactic acid bacteria colonies were subcultured on 90% of Trypton Soya agar and 10% of Main Rogosa (MRS) agar. After incubation at 30 °C for 18 – 24 h microaerobically. One colony of each bacterial isolate was selected for screening. Subsequently, an analysis of the bacteria identification was performed using the MALDI-TOF MS Biotyper.

**Bacterial strains for testing**

*Escherichia coli* CCM 3988, *Klebsiella pneumoniae* CCM 2318, *Salmonella enterica* subsp. *enterica* CCM 3807, *Pseudomonas aeruginosa* CCM 1959, *Yersinia enterocolitica* CCM 5671 and five of Gram-positive bacteria: *Bacillus thuringiensis* CCM 19, *Micrococcus luteus* CCM 732, *Listeria monocytogenes* CCM 4699, *Staphylococcus aureus* subsp. *aureus* CCM 2461, *Streptococcus pneumoniae* CCM 4501 were obtained from the Czech collection of microorganisms (Brno).

**Antibacterial activity of LAB isolate**

The culture of lactic acid bacteria after 24 h of incubation in MRS broth (Oxoid, Basingstoke, UK) was centrifuged at 5500 g for 10 min at 4 °C and 2 mL of the supernatant was used for detection of antibacterial activity.

The well diffusion assay was used. Bacteria were spread on Petri dishes with MRS agar. LAB isolates were added in 6 mm diameter wells were created into the agar. The amounts of LAB and indicator bacteria were the same (100 μl, 10⁸ CFU/mL) prepared from the broth culture of bacteria according to the 0.5 McFarland standard. After 48 h incubation at 37 °C in an aerophilically chamber, the inhibition zone diameter was measured for detection of the antagonistic effect of the LAB isolate against pathogenic bacteria.

**Statistical analyses**

The mean and standard deviation of inhibition zones was calculated for the detection of antagonistic effect against tested Gram-positive and Gram-negative bacteria.

**RESULTS AND DISCUSSION**

LAB antimicrobial products, such as bacteriocins, are very important in bioconservation of various foods. The diverse use of LAB bacteriocins, individually or as biopreservation combinations, may help to improve food safety, especially of traditional products (Jamuna and Jeevaratnam, 2004; Mojgani and Aminia, 2007).

In our study 130, lactic acid bacteria isolated from ewes’ cheese bryndza (Table 1) were tested for antimicrobial activity and antagonistic effect against pathogenic gram-positive and Gram-negative bacteria.

In agar test, lactic acid bacteria isolated from ewes’ cheese bryndza demonstrated different antimicrobial activity with the inhibition the zone ranged from <1 to >5 mm. Altogether, 92% of LAB showed activity against *Yersinia enterocolitica*, 91% against *Klebsiella pneumoniae*, 88% against *Escherichia coli*, 84% against *Listeria monocytogenes*. Antimicrobial activity lower than 84% was observed against *Salmonella enterica* subsp. *enterica*, *Pseudomonas aeruginosa*, *Bacillus thuringiensis*, *Micrococcus luteus*, *Staphylococcus aureus* subsp. *aureus*, and *Streptococcus pneumoniae* (Table 2). Belicová et al. (2013) tested 125 acid resistant presumptive lactobacilli isolated from bryndza against *Listeria monocytogenes* CCM 4699, *Staphylococcus lentus* CCM 3472, *Actinobacter calcoaceticus* CCM 4503, *Sphingomonas paucimobilis* CCM 3293, and *Salmonella enterica* subsp. *enterica*, serovar Typhimurium.

LAB produces metabolites such as organic acids (lactic and acetic acid), hydrogen peroxide, ethanol, diacetyl, acetaldehyde, acetoin, carbon dioxide, and bacteriocins that were classified as antimicrobial agents. Moreover, the production of organic acids resulted in low pH, which also inhibits the activity of pathogenic microorganisms (Ponce et al., 2008; Šuškovič et al., 2010). Antibacterial activity of organic acids and bacteriocins was confirmed against various pathogenic Gram-positive and Gram-negative microorganisms (Maragkoudakis et al., 2009).

A total of 20 LAB isolates showed strong inhibition zones (more than 5 mm) against *P. aeruginosa* and *M. luteus*. Nineteen of LAB isolates showed strong antimicrobial activity against *S. aureus*. Cell suspension of *Lactobacillus plantarum* inhibited *L. monocytogenes* growth (Ennahar et al., 1998). *Lactococcus lactis* reduced levels of *L. monocytogenes* in Cheddar cheese (Buyong et al., 1998). Lactococci developed by Reviriego et al. (2005) and Reviriego et al. (2007) reduced the number of *L. innocua*, *L. monocytogenes*, *S. aureus*, and *E. coli* in cheese (Rodriguez et al., 2005). The intermediate inhibitory effect against Gram-negative and Gram-positive bacteria (1 – 5 mm) is shown in Figure 1. The most effective strains were *Lactobacillus paracasei* ssp. *paracasei* against all tested pathogens. This bacteria exhibited inhibitory activity against all 10 bacteria tested with 2 to 8 isolated were active against particular bacteria.
Foodborne pathogens have become an important social concern because of frequent foodborne outbreaks. In previous studies, LAB showed a wide range of antimicrobial effects against many foodborne pathogens (Soerjadi et al., 1981; Ennahar and Deschamps, 2000; Messens and De Vuyst, 2002; Dodd, 2012). Studies of interaction between LAB and L. monocytogenes in various media and with various LAB strains have been performed, and in all cases LAB inhibited the growth of L. monocytogenes (Tharrington and Sorrells, 1992; Zhang et al., 2011; Zhu et al., 2014).

However, Kao and Frazier (1966) obtained a mixed result when LAB was cocultured with S. aureus. Many researchers have found that LAB can inhibit Salmonella (Keersmaecker et al., 2006; Zhang et al., 2016; Yang et al., 2017) and that the bacteriostatic substances produced by LAB are thermally stable. The research focused on the inhibition of E. coli by LAB is more extensive compared to inhibition of the other bacteria. Du et al. (2016) found three strains of Lactobacillus acidophilus which could inhibit E. coli ATCC 25922. Other investigations on E. coli O157:H7 proliferation control showed that LAB could effectively inhibit the growth of E. coli O157:H7 (Brashears et al., 1998; Fooladi et al., 2014). Klebsiella pneumonia, Pseudomonas aeruginosa, Enterococcus hirae, and Candida albicans (Yu et al., 2006) also can be inhibited by LAB.

### Table 2 Number of lactic acid bacteria isolates with antimicrobial effect against pathogenic bacteria in mm.

| Inhibition zone | EC | KP | SEE | PA | YE | BT | ML | LM | SAA | SP |
|-----------------|----|----|-----|----|----|----|----|----|-----|-----|
| <1              | 5  | 4  | 10  | 15 | 5  | 15 | 20 | 6  | 11  | 15  |
| 1 – 5           | 115| 118| 105 | 95 | 120| 105| 90 | 110| 140 | 19  |
| >5              | 10 | 8  | 15  | 20 | 5  | 10 | 20 | 14 | 19  | 14  |

Note: EC – Escherichia coli; KP – Klebsiella pneumoniae; SEE – Salmonella enterica subsp. enterica; PA – Pseudomonas aeruginosa; YE – Yersinia enterocolitica; BT – Bacillus thuringiensis; ML – Micrococcus luteus; LM – Listeria monocytogenes; SAA – Staphylococcus aureus subsp. aureus; SP – Streptococcus pneumoniae.

**Figure 1** The inhibitory activity of the most active predictive lactic acid isolates against the pathogenic strains. Note: EC – Escherichia coli; KP – Klebsiella pneumoniae; SEE – Salmonella enterica subsp. enterica; PA – Pseudomonas aeruginosa; YE – Yersinia enterocolitica; BT – Bacillus thuringiensis; ML – Micrococcus luteus; LM – Listeria monocytogenes; SAA – Staphylococcus aureus subsp. aureus; SP – Streptococcus pneumoniae.
Table 3 Antagonistic effect of lactic acid bacteria against Gram-negative and Gram-positive bacteria in mm (mean±zone of inhibition of 10 isolates ±3D).

| LAB                  | EC   | KP   | SEE  | PA   | YE   | BT   | ML   | LM   | SAA  | SP   |
|----------------------|------|------|------|------|------|------|------|------|------|------|------|
| Enterococcus faecalis| 3.70±2.31 | 3.70±1.25 | 3.30±2.06 | 3.30±1.16 | 3.60±1.07 | 2.40±1.07 | 2.70±1.16 | 2.90±0.87 | 2.50±0.53 | 2.40±0.70 |
| Enterococcus faecium  | 3.90±1.73 | 3.40±1.51 | 3.10±2.08 | 3.40±1.00 | 3.20±1.23 | 2.50±0.97 | 2.60±0.97 | 2.60±0.52 | 2.50±1.18 | 2.50±1.08 |
| Enterococcus hirae    | 3.40±1.78 | 3.20±1.40 | 3.00±2.00 | 3.20±1.03 | 3.00±0.82 | 2.00±0.47 | 2.50±0.85 | 2.70±0.68 | 2.20±1.14 | 2.70±1.34 |
| Lactobacillus brevis  | 4.10±1.79 | 3.80±2.10 | 3.70±2.41 | 3.80±2.10 | 4.40±0.97 | 2.60±1.07 | 2.70±0.67 | 2.90±0.74 | 2.60±1.35 | 3.00±1.70 |
| Lactobacillus helveticus| 4.30±1.49 | 4.20±1.87 | 4.70±1.06 | 4.10±2.02 | 4.60±0.84 | 3.00±1.15 | 3.00±0.47 | 3.00±0.67 | 3.00±1.41 | 3.40±2.32 |
| Lactobacillus johnsonii| 4.60±1.27 | 4.40±1.58 | 4.20±2.30 | 4.40±2.07 | 4.70±0.67 | 2.70±1.25 | 3.10±0.32 | 3.20±0.42 | 3.50±1.51 | 3.20±2.54 |
| Lactobacillus plantarum| 4.70±0.46 | 5.10±1.73 | 4.50±2.01 | 4.70±2.06 | 4.80±0.42 | 2.90±1.18 | 3.30±0.67 | 3.10±0.57 | 3.60±1.35 | 3.50±2.42 |
| Lactobacillus paracasei sp. paracasei| 4.90±0.88 | 5.30±1.57 | 5.10±2.08 | 4.90±1.85 | 4.90±0.31 | 3.00±1.05 | 3.60±1.07 | 3.40±0.70 | 3.80±1.69 | 3.50±2.84 |
| Lactobacillus paraplanatum| 5.00±0.67 | 5.40±1.58 | 5.60±1.84 | 4.80±1.81 | 4.80±0.42 | 3.20±1.03 | 3.70±1.06 | 3.60±0.84 | 3.90±1.66 | 3.70±2.87 |
| Lactobacillus suecicus| 4.80±0.63 | 5.30±1.57 | 5.00±1.76 | 4.50±1.18 | 4.90±0.57 | 3.30±0.95 | 3.50±0.71 | 3.50±0.71 | 4.00±1.56 | 3.80±2.78 |
| Lactobacillus lactis subsp. lactis| 5.10±0.74 | 5.50±1.65 | 5.00±1.70 | 4.70±1.25 | 5.00±0.67 | 3.40±0.84 | 3.60±1.35 | 3.40±0.84 | 3.90±1.45 | 3.80±2.62 |
| Lactobacillus lactis| 4.90±0.99 | 5.30±1.57 | 5.40±1.71 | 4.40±1.27 | 4.80±0.92 | 3.30±0.82 | 3.60±1.51 | 3.20±1.14 | 3.90±1.37 | 3.90±2.51 |
| Pediococcus acidilactici| 4.40±1.51 | 4.60±1.51 | 4.30±1.83 | 4.10±2.20 | 4.40±1.51 | 3.00±1.05 | 3.00±0.84 | 2.90±1.29 | 3.30±1.16 | 3.20±2.20 |

Note: EC – Escherichia coli; KP – Klebsiella pneumoniae; SEE – Salmonella enterica subsp. enterica; PA – Pseudomonas aeruginosa; YE – Yersinia enterocolitica; BT – Bacillus thuringiensis; ML – Micrococcus luteus; LM – Listeria monocytogenes; SAA – Staphylococcus aureus subsp. aureus; SP – Streptococcus pneumoniae.

CONCLUSION

In conclusion, the present study of lactic acid bacteria strains isolated from ewes’ cheese bryndza confirmed antagonistic effect against Gram-negative and Gram-positive bacteria.

In our study, the best results were found for Lactococcus lactis subsp. lactis against Salmonella enterica subsp. enterica. In vitro screening of LAB from Slovak bryndza ewes’ cheese have good potential for use as probiotic cultures.

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