Evaluation of whey permeate obtained through nanofiltration for the formulation sports drinks

Avaliação do permeado de soro obtido por nanofiltração para a formulação de bebidas esportivas

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Alexandra Fabióla Becker
Mestre em Ciência e Tecnologia de Alimentos
Universidade do Estado de Santa Catarina
Food Engineering and Chemical Engineering Department, Santa Catarina State University (UDESC), BR 282, km 573, Post Code 89870-000, Pinhalzinho, Santa Catarina State, Brazil
E-mail:alexandraf.becker@gmail.com

Eduardo Rebelatto
Graduado em Engenharia de Alimentos
Universidade do Estado de Santa Catarina
Food Engineering and Chemical Engineering Department, Santa Catarina State University (UDESC), BR 282, km 573, Post Code 89870-000, Pinhalzinho, Santa Catarina State, Brazil
E-mail:du_rebelatto@hotmail.com

Karina Sabadin
Graduada em Engenharia de Alimentos
Universidade do Estado de Santa Catarina
Food Engineering and Chemical Engineering Department, Santa Catarina State University (UDESC), BR 282, km 573, Post Code 89870-000, Pinhalzinho, Santa Catarina State, Brazil
E-mail:karina-sabadin@hotmail.com

Jenefher Becker
Mestre em Engenharia de Alimentos
Universidade Regional Integrada do Alto Uruguai e das Missões (URI)
Food Engineering Department, Integrated Regional University of Alto Uruguai and of Missões (URI), Av. Sete de Setembro, 1621, Bairro Fátima, Post Code 99709-910, Erechim, Rio Grande do Sul State, Brazil
E-mail:jenefherbecker@unochapeco.edu.br

Juliana Steffens
Doutora em Engenharia Química
Universidade Regional Integrada do Alto Uruguai e das Missões (URI)
Food Engineering Department, Integrated Regional University of Alto Uruguai and of Missões (URI), Av. Sete de Setembro, 1621, Bairro Fátima, Post Code 99709-910, Erechim, Rio Grande do Sul State, Brazil
E-mail:julisteffens@uricer.edu.br

Lucíola Bagatini
Mestre em Ciências de Alimentos
Universidade do Estado de Santa Catarina
Food Engineering and Chemical Engineering Department, Santa Catarina State University (UDESC), BR 282, km 573, Post Code 89870-000, Pinhalzinho, Santa Catarina State, Brazil
E-mail:luciola.bagatini@udesc.br

Darlene Cavalheiro
Doutora em Engenharia de Alimentos
Universidade do Estado de Santa Catarina
Food Engineering and Chemical Engineering Department, Santa Catarina State University (UDESC), BR 282, km 573, Post Code 89870-000, Pinhalzinho, Santa Catarina State, Brazil
E-mail:darlene.cavalheiro@udesc.br

Elisandra Rigo
Doutora em Engenharia de Alimentos
Universidade do Estado de Santa Catarina
Food Engineering and Chemical Engineering Department, Santa Catarina State University (UDESC), BR 282, km 573, Post Code 89870-000, Pinhalzinho, Santa Catarina State, Brazil
E-mail:elisandra.rigo@udesc.br

ABSTRACT

Whey derives from cheese production and is used either in its original form or concentrated in dairy drinks and food products. The whey concentration process generates permeate, which is composed of water and minerals. An alternative for the use of whey permeate is in beverage products. Then, it is important to evaluate its physicochemical properties and sensory aspects of sports drinks formulated with this waste. Different sodium concentrations (0,024, 0,030 and 0,40%) were tested and the intermediate concentration achieved the best results in terms of osmolality in accordance with the standard of current legislation. For the sensory analysis, different concentrations of lemon flavor (0,02, 0,04 and 0,06%) were used, all of which differed significantly ($p<0,05$) from the commercial sports drink, but the 0,02% concentration had the smallest difference (1,47). The present findings demonstrate the potential of use of whey permeate obtained from nanofiltration for the formulation of sports drinks.

Keywords: minerals, osmolality, whey permeate, nanofiltration, sports drinks.

RESUMO
O soro é derivado da produção de queijo e é utilizado em sua forma original ou concentrado em bebidas lácteas e produtos alimentícios. O processo de concentração do soro gera o permeado, que é composto de água e minerais. Uma alternativa para o uso de permeado de soro de leite é em bebidas. Assim, é importante avaliar suas propriedades físico-químicas e aspectos sensoriais das bebidas esportivas formuladas com esses resíduos. Foram testadas diferentes concentrações de sódio (0,024, 0,030 e 0,40%) e a concentração intermediária obteve os melhores resultados em termos de osmolalidade de acordo com o padrão da legislação em vigor. Para a análise sensorial foram utilizadas diferentes concentrações de sabor limão (0,02, 0,04 e 0,06%), todas diferiram significativamente (p <0,05) da bebida esportiva comercial, exceto 0,02% de concentração que teve a menor diferença (1,47). Estes resultados demonstram o potencial de uso do permeado de soro obtido da nanofiltração para a formulação de bebidas esportivas.

Palavras-chave: minerais, osmolalidade, permeado de soro de leite, nanofiltração, bebidas esportivas.

1 INTRODUCTION

Whey is obtained from the production of cheese. It corresponds to 80 to 90% of the total milk volume and contains soluble proteins, lactose, vitamins, minerals and a minimal amount of fat (ALVES et al., 2014). Whey has applications in food supplements, ice creams, cakes, juices and chocolates and is also used in its original form to produce dairy drinks and ethanol, (VIAPIANA, 2017; PARASHAR et al., 2016), and thermogenic drink (da SILVA JUNIOR et al., 2020).

To add value, whey can be concentrated through membrane systems [ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO)], which are widely used for reuse of whey components by the dairy industry (ILTCHENCO et al., 2018). NF is used in desalination and wastewater treatment as well as the food and pharmaceutical industries (TOUATI et al., 2018; RODRIGUEZ et al., 2017; ZACHAROF et al., 2016; WOODS et al., 2016; ZHOU et al., 2015).

Membrane separation operations generate two products: the concentrate with the majority of the components, depending on the pore size of the membrane; and the permeate, which is mainly composed of water and particles that permeate the membrane (DESCONSI; IZÁRIO FILHO; SALAZAR, 2014). The permeate is a promising raw material for use in sports drink formulations due to the presence of minerals that can help in rehydration following physical activity (FONTES et al., 2015; BALDASSO; BARROS; TESSARO, 2011).

Sports drinks or hydroelectrolytic supplements have a formulation similar to blood plasma, which facilitates absorption by the body (BRASIL, 2010). According to RDC Resolution no. 18 of April 27, 2010 of ANVISA [Brazilian Health Regulatory Agency] (BRASIL, 2010), sports drinks are supplements formulated for the replacement of water and electrolytes in individuals who practice physical activity.

Since whey permeate is rich in minerals, the aim of the present study was to use permeate obtained through nanofiltration as the basis of a lemon-flavored sports drink as well as assess the physicochemical and sensory properties of different formulations.

2 MATERIALS AND METHODS

2.1 RAW MATERIAL

Whey derived from the production of mozzarella cheese from a dairy industry in the western portion of the state of Santa Catarina, Brazil, was previously centrifuged and submitted to a spiral membrane nanofiltration system in three stages (modified ALCROSS, TeM Ro Lite – BR_10043871), with a molecular mass of 200 Da, at 19-25 bar pressure and temperature between 8 and 11 °C in a sanitary spiral with an external microfiber wrap. Whey permeate samples were obtained during four collections (C1, C2, C3 and C4) performed at different times of the year. The samples (20 liters each) were submitted to a slow pasteurization process in a Thermomix™ (Vorwerk, Bimby®, TM5 model) at 65 °C for 30 min, then cooled at 5 ºC and stored in tagged sterilized lidded plastic recipients for freezing in a vertical freezer at - 4 ºC (Consul, CVU26E) until testing.

2.2 FORMULATION OF SP
ORTS DRINK

The base formulation for the sports drink consisted of 6,00% sucrose, 0,02% stabilizer (ICL Foods Specialties), 0,04% source of calcium (ICL Foods Specialties), 0,02% source of potassium (ICL Foods Specialties), 0,03% source of magnesium (ICL Foods Specialties), 0,18% anhydrous citric acid P.A. (Cinética) and 0,02% lemon flavor (Duas Rodas). The sodium concentration (Lafan) was varied, resulting in Formulation 1 (F1, 0,024%), Formulation 2 (F2, 0,030%) and Formulation 3 (F3, 0,040%).

The ingredients were added to 2 L of permeate, submitted to slow pasteurization (30 min to 65 °C) in a Thermomix™, then cooled to 5 ºC and stored in lidded plastic recipients.

For the sports drink formulation with mineral content in compliance with current legislation (F2), different concentrations of lemon flavor were tested for sensory analysis:

F_{2A} formulation = 0,02%; F_{2B} formulation = 0,04%; and F_{2C} formulation = 0,06%. The aim of the added lemon flavor was to mask the residual flavor of the raw material.

2.3 PHYSICOCHEMICAL ANALYSES

The following physicochemical analyses were conducted for the characterization of the whey permeate: fixed mineral residue in a muffle (Quimis, Q318M24 model) (INSTITUTO ADOLFO LUTZ, 1985); calcium, magnesium, sodium and potassium contents using method no. 985.35 (AOAC, 2016) and readings performed by flame atomic absorption spectrometry (FAAS; VarianSpectra AA-55) according to method 990.08 described in AOAC (2016); pH using a pH meter (Tecnopon mPA 210 model); titratable acidity (Brasil, 2018); lactose using a kit (Enzymatic BioAnalysis/Food Analysis, ROCHE, R-158 BIOPHARM AG, 2018); nitrogen-to-protein conversion factor (6,38) (BRASIL, 2018); lipids using the Gerber method (BRASIL, 2018); and osmolality (GOMES; OLIVEIRA, 2011). These same analyses, except titratable acidity and protein, were conducted for the sports drink. Soluble solids were also determined for the drink samples using a benchtop refractometer (Hanna, HI 96801 model).

2.4 MICROBIOLOGICAL ANALYSES

The total aerobic mesophilic bacterial count was performed according to Santos, Alves and Lima (2013) and Fontes et al. (2015) for the whey permeate before pasteurization and the sports drink after pasteurization.

2.5 SENSORY ANALYSIS

The sensory analysis of the drinks was performed using the Control Difference Test to determine whether tasters could identify significant differences among the samples with different concentrations of lemon flavor. The drinks were denominated A (0,02% flavor), B (0,04% flavor) and C (0,06% flavor). A commercial sports drink was used as the control sample. Samples (50 mL) were submitted to the sensory analysis of 50 untrained tasters, who were asked to taste the samples and compare them to the control sample on a scale of 0 (no difference from control) to 9 (extremely different). The samples were served at a temperature of 4 °C. Prior to the sensory analysis, the project received approval from the UDESC Research Ethics Committee (certificate number: 59999616.8.0000.0118).

2.6 STATISTICAL ANALYSIS

The permeate was collected in replicates and the isotonic formulations were prepared in batch replication. The analyses were conducted considering triplicate experiments. The results were submitted to analysis of variance (ANOVA) and the LSD mean comparison test using the Statistic trial 13.2, considering a 95% confidence level ($p < 0,05$).

3 RESULTS AND DISCUSSION

3.1 ASSESSMENT OF WHEY PERMEATE AT DIFFERENT TIMES OF YEAR

The values obtained for the whey nanofiltration permeate with regards to lactose (<0,10%), lipids (0,00%) and protein content (0,66%) were lower those found in the whey (4,37%, 0,05% and 5,49%, respectively). These results were expected, as nanofiltration (NF) retains molecules between 0,002 and 0,01 μm (XU et al., 2017), i.e., the efficiency of the filtration process is in line with the lactose/lipid concentration found in the permeate.

NF membranes are appropriate for dairy applications due to the permeability for monovalent ions (40 to 90%) and the restriction of multivalent ions (5 to 20%), sugars, dyes and small organic molecules (TOUATI et al., 2018). As lactose is a carbohydrate, the value obtained indicates the possibility of using the permeate in the production of sports drinks in accordance with Brazilian legislation (BRASIL, 2010), which stipulates a maximum concentration of 8% carbohydrates for this type of drink.

Regarding titratable acidity (Table 1), C3 differed significantly ($p < 0,05$) from the other permeates. No significant differences among the permeates were found for fixed mineral residue ($p > 0,05$), except for C1, which had values on the same order of magnitude as those described in a study conducted by Fontes et al. (2015), who found 0,41 ± 0,02% for a permeate obtained through ultrafiltration; a greater value than that found for C1 may be due to the difference in the membrane used in the separation process.

The pH values differed significantly ($p < 0,05$) and were lower than that described for ultrafiltered milk permeate reported by Faedo et al. (2013) (6,70). This difference may be related to the type of membrane used in the whey concentration process and the separation of specific ionic groups (TOUATI et al., 2018) as well as the type of coagulation used to obtain the whey. In the production of acid cheeses, demineralization of the mass occurs due mainly to the exiting of calcium form the casein complex to the whey, which is inherent to the process (temperature and pH) (FOX et al., 2004).

Osmolality differed significantly ($p < 0,05$) between C3 and the other permeates, which may be related to the weather and/or animal feed (TEIXEIRA, 2015). Osmolality (Table 1) was below the range required for sports drinks stipulated in Brazilian legislation (330 mOsm.kg.water^{-1}), which demonstrates that the supplementation of minerals (sodium, potassium and magnesium) to the permeate is necessary for a drink of this type.

Flores et al. (2015) obtained values of 212,1 mOsm.kg.water^{-1} through the ultrafiltration of milk. According to Habert, Borges and Nobrega (2006), pore size in ultrafiltration ranges from 0,01 to 0,1 μm, retaining fewer compounds in comparison to nanofiltration, which retains lactose and other milk components, only enabling the permeation of soluble monovalent ions and water (CARVALHO; MAUBOIS, 2010).

Table 1. Physico-chemical characterization of whey permeate obtained from the nanofiltration process in different collections

Evaluated Parameters	C1	C2	C3	C4
Titratable Acidity (% lactic acid)	0,03 ± 0,00^{b}	0,03 ± 0,00^{b}	0,04 ± 0,00^{a}	0,03 ± 0,00^{b}
pH	6,15 ± 0,03^{ab}	6,09 ± 0,02^{b}	6,16 ± 0,01^{a}	6,10 ± 0,00^{b}
Fixed Mineral Residue (%)	0,37 ± 0,00^{a}	0,29 ± 0,00^{b}	0,33 ± 0,00^{b}	0,33 ± 0,02^{b}
Osmolality (mOsm.kg.water^{-1})	105,81 ± 7,23^{b}	101,88 ± 0,38^{b}	124,47± 0,00^{a}	104,77± 0,00^{b}
lcium (mg.L^{-1})	117,75 ± 7,05^{b}	62,42± 0,71^{c}	75,45±6,36^{c}	138,53 ± 5,45^{a}
Magnesium (mg.L^{-1})	21,95 ± 2,82^{b}	17,98± 1,41^{b}	62,96 ± 26,85^{a}	22,29 ± 2,82^{b}
Sodium (mg.L^{-1})	326,8 ± 3,53^{b}	347,56 ±38,14^{b}	514,18 ± 20,49^{a}	300,30 ± 62,14^{b}
Potassium (mg.L^{-1})	825,74 ± 14,65^{a}	668,55 ± 17,66^{b}	604,62 ± 19,87^{b}	513,62 ± 2,40^{c}

Means ± standard deviation followed by the same lowercase letters in each line do not differ significantly (p <0,05) in relation to the parameters evaluated in different collections (C) (Tukey Test).

No significant difference in calcium concentration was found between C2 and C3 (p > 0,05). However, a significant difference was found between C1 and C4 (p < 0,05), possibly due to the chemical characteristics of the milk, as the calcium concentration in milk is related to the season of the year, lactation stage, type of feed and the genetics of the dairy cows (SCHWENDEL et al., 2015, LIN et al., 2017) as well as environment factors, such as milk coagulation and the cheese making process (GAUCHERON, 2011).

No significant difference was found for magnesium (p > 0,05). In a study on permeate obtained from the ultrafiltration of milk, Flores et al. (2015) reported a magnesium content of 52,04 mg.L^{-1}, which is similar to the value found for C3 in the present study. Differences in magnesium content are mainly related to genetic factors of the animals (TEIXEIRA, 2015), type of feed and environmental factors.

A significant difference in sodium content (p < 0,05) was only found for C3. Sabioni et al. (2016) found a sodium content of 460,99 mg.L^{-1} in permeate obtained through the ultrafiltration of whey. The pore size of the membrane affects the type and concentration of ions in the permeate. Ultrafiltration is a separation process involving a membrane to retain macromolecules (BALDASSO; BARROS; TESSARO, 2011), whereas nanofiltration retains low-weight molecules, such as Na^+.

No significant difference in potassium content ($p > 0,05$) was found between C2 and C3. C1 had a higher potassium content than that stipulated by legislation (maximum of 700 $mg.L^{-1}$). Fontes et al. (2015) reported similar values (763,5 $mg.L^{-1}$ of potassium) for permeate obtained through the ultrafiltration of milk. It should be noted that, along with sodium and magnesium, potassium is one of the main minerals that should compose sports drinks (ROTSTEIN et al., 2013).

Mineral content assists in athletic performance (POUND; BLAIR, 2017), ensures rapid energy to the body during physical activity and also influences the recovery of the body after training (SIMULESCU et al., 2019). Potassium is a key mineral for cell functions, such as the transport of oxygen and osmotic regulation, and participates in muscle contractions (MORENO-ROJAS; CAMARA-MARTOS; AMARO LOPEZ, 2016), which are essential during training.

3.2 CHARACTERIZATION OF SPORTS DRINK FORMULATIONS PREPARED WITH WHEY NANOFILTRATION PERMEATE WITH DIFFERENT SODIUM CONCENTRATIONS

Table 2 displays the values for minerals (Ca, Mg, Na and K) and osmolality of the sports drink with different sodium concentrations prepared with the C3 permeate. Osmolality differed significantly ($p < 0,05$) among the three formulations, but the values were in compliance with Brazilian legislation (lower than 330 $mOsm.kg.water^{-1}$) (BRASIL, 2010). This variable depends on the content of minerals and carbohydrates. The number of osmotic particles per mass unit of the drink must be the same as that found in human blood, which usually varies from 280 to 290 $mOsm.kg.water^{-1}$ (METTLER; RUSCH; COLOMBANI, 2006). The electrolytes in sports drinks are then transferred to and incorporated into the blood stream through the osmotic process.

The addition of sucrose within the limit stipulated by legislation (8,00%) was performed with the aim of masking the astringency of the drink due to the presence of minerals in greater concentration, resulting in the addition of solutes and also contributing to the increase in the osmolality of the drink.

No significant differences were found regarding the mineral contents ($p >0,05$).

Magnesium values were close to that obtained by Ferreira et al. (2020) for a sports drink prepared from whey ultrafiltration with jabuticaba peel extract (62 $mg.L^{-1}$). The same is seen with the concentrations of sodium, which were similar to the values found by Ferreira et al. (2020) (608,4 $mg.L^{-1}$) and are in accordance with legislation (460 to 1150 $mg.L^{-1}$). Electrolytes (sodium, chloride and potassium) help replace the loss of sweat (MEYER et al., 2019).

Table 2. Characterization of the isotonic drink made with permeate from whey nanofiltration with different concentrations of sodium: F1 (0,024 %), F2 (0,030 %) e F3 (0,040 %)

Evaluated Parameters	Sodium Concentrations (%)		
	F1	F2	F3
Osmolality (mOsm.kg.water^{-1})	298,67 ± 0,01^{b}	297,04 ± 0,05^{c}	311,02 ± 0,01^{a}
Calcium ($mg.L^{-1}$)	320,21 ± 7,31^{a}	306,78 ± 3,00^{a}	390,85 ± 115,59^{a}
Magnesium ($mg.L^{-1}$)	26,31 ± 8,28^{a}	27,82 ± 6,14^{a}	25,94 ± 5,95^{a}
Sodium ($mg.L^{-1}$)	509,09 ± 13,88^{a}	617,70 ± 143,94^{a}	713,79 ± 164,77^{a}
Potassium ($mg.L^{-1}$)	579,74 ± 171,07^{a}	657,65 ± 16,81^{a}	854,25 ± 10,58^{a}

Means ± standard deviation followed by the same lowercase letters in each line do not differ significantly (p <0,05) in relation to the parameters evaluated in the different sodium concentrations (Tukey Test).

Regarding potassium, only the formulation with 0,040% sodium was above the limit established by legislation, which imposes a maximum of 700 $mg.L^{-1}$ (BRASIL, 2010). This mineral is usually found in commercial sports drinks at concentrations similar to those found in blood plasma and sweat (SHIRREFFS; MAUGHAN, 1997). Considering osmolality (297,04 mOsm.kg.water^{-1}) and the concentration of minerals (617,70 $mg.L^{-1}$ of sodium and 657,65 $mg.L^{-1}$ of potassium), C2 with 0,030% sodium was selected for the characterization of the sports drink and sensory evaluation with different concentrations of lemon flavor.

3.3 CHARACTERIZATION OF SPORTS DRINK FORMULATIONS PREPARED WITH DIFFERENT CONCENTRATIONS OF LEMON FLAVOR

Table 3 displays the characterization of the formulations prepared for the sensory analysis involving different concentrations of lemon flavor, which is often used in sports drinks. The other ingredients were at fixed concentrations, including the 0,030% sodium, which achieved the best values in compliance with legislation regarding sports drinks.

No significant difference in acidity was found (p > 0,05) among the formulations with different flavor concentrations. The values for this variable were lower than that described by Ferreira et al. (2020) for a sports drink formulated with whey ultrafiltration permeate supplemented with jabuticaba peel extract.

Table 3. Evaluation of isotonic drink formulations made with permeate from cheese whey nanofiltration with different concentrations of lemon flavor, $F_{2,A}$ (0,02%), $F_{2,B}$ (0,04%) e $F_{2,C}$ (0,06%)

Evaluated Parameters	Formulations		
	$F_{2,A}$	$F_{2,B}$	$F_{2,C}$
Titratable Acidity (%)	0,40 ± 0,03[a]	0,39 ± 0,02[a]	0,38 ± 0,01[a]
pH	2,39 ± 0,01[a]	2,41± 0,01[a]	2,41 ± 0,01[a]
Lipid (%)	0,01±0,00[a]	0,01±0,00[a]	0,01±0,00[a]
Protein (%)	0,66±00[a]	0,65±0,01[a]	0,66±0,01[a]
Lactose (%)	<0,10±0,00[a]	<0,10±0,00[a]	<0,10±0,00[a]
Fixed Mineral Residue (%)	0,34±0,00[a]	0,33±0,00[a]	0,33±0,00[a]
Total Soluble Solids (°Brix)	6,10 ± 0,01[c]	6,20 ± 0,02[b]	6,31± 0,01[a]
Osmolality (mOsm.kg.water^{-1})	295,00 ± 0,03[a]	298,04 ± 0,08[a]	297,09 ± 0,01[a]
Calcium (mg.L^{-1})	389,78 ± 25,29[a]	375,21 ± 22,81[a]	359,55 ± 25,82[a]
Magnesium (mg.L^{-1})	60,02 ± 9,00[a]	57,12 ± 6,77[a]	53,56 ± 10,13[a]
Sodium (mg.L^{-1})	663,38 ± 13,75[a]	678,86 ± 11,37[a]	745,66 ± 79,03[a]
Potassium (mg.L^{-1})	622,44 ± 48,9[a]	634,03 ± 50,93[a]	594,12 ± 16,50[a]

Means ± standard deviation followed by the same lowercase letters in each line do not differ significantly (p <0,05) in relation to the parameters evaluated in the different concentrations of lemon flavor (Tukey Test).

No significant difference in pH was found (p > 0,05) among the formulations. In a study involving the addition of buriti oil nanoemulsions to a sports drink, Bovi, Petrus and Pinho (2017) found pH 2,92. Ferreira et al. (2020) reported pH 3,40 for a sports drink formulated with whey ultrafiltration permeate supplemented with jabuticaba peel extract. These low values contribute to the conservation of the product.

The contents of fat, protein and lactose were the same as those originally obtained for the permeate, since there was no addition of any ingredient that might cause a change in these variables. Regarding the fixed mineral residue, no significant differences were found among the three formulations, indicating that the addition of flavor exerted no influence on this variable.

The total soluble solids (°Brix) differed significantly among the three formulations (p <0,05). In contrast, Valente (2015) and Ferreira et al. (2020) reported 5,83 °Brix.

Osmolality ranged from 295 to 298 mOsm.kg.water^{-1}. This range is in compliance with legislation, which imposes a maximum of 330 mOsm.kg.water^{-1} for this type of drink (BRASIL, 2010). Sports drinks have osmolality within the range found in human blood plasma (285 to 295 mOsm.kg.water^{-1}). Therefore, the formulations proposed are within the standards for commercialization.

According to current Brazilian legislation (BRASIL, 2010), concentrations of sodium and potassium must be 460 to 1150 mg.L^{-1} and up to 700 mg.L^{-1}, respectively.

The values obtained for these minerals in the present study (Table 3) are in compliance with these limits. Moreover, no significant differences ($p > 0,05$) were found in the content of these minerals among the three formulations, which was expected, as flavor was the only aspect altered in this phase of the study.

Regarding the microbiological count of aerobic mesophilic bacteria, the samples of whey permeate *in natura* and the sports drink formulated for the sensory analysis had values of $1,07 \times 10^3$ and $<1,0 \times 10^1$ CFU.mL^{-1}, respectively. The permeate underwent pasteurization in a Thermomix™ to lower the risk of microbiological contamination and the result is in agreement with the value described in the study by Valente (2015) ($<1,0 \times 10^1$ CFU.mL^{-1}). There is no ordinance establishing microbiological standards for sports drinks, but ANVISA RDC Resolution nº 12 (BRASIL, 2001) establishes microbiological standards for juices, refreshments, soft drinks and other non-alcoholic drinks, excluding dairy-based and chocolate drinks. The resolution recommends that the product have no coliforms at 35 ºC. The results obtained in this study are in line with this recommendation.

3.4 SENSORY EVALUATION OF SPORTS DRINKS

Table 4 displays the results of the Control Difference Test. All samples tested differed significantly ($p <0,05$, Dunnett's test) from the control (commercial sample). With regards to the global attributes, the fact that the judges detected differences between the test samples and the commercial sample is noteworthy. Based on the range values, a moderate difference was found among the samples.

In a study involving a sports drink with the addition of Buriti oil nanoemulsions, Bovi, Petrus and Pinho (2017) found that the greatest difference among the samples in the paired comparisons was due to the flavor attribute, indicating that flavor has the most weight in tasters' decisions when testing such products. Passe et al. (2009) found differences in the acceptance of sports drinks related to the duration of exercises performed by the consumers during the tests, the concentration of sodium added to the drinks and the influence of different concentrations on the perception of the taste of the drink.

Table 4. Comparison between commercial isotonic drink (Control) and isotonic drinks with whey permeate added with different concentrations of lemon flavor: Sample $F_{2,A}$ (0,02%), Sample $F_{2,B}$ (0,04%) e Sample $F_{2,C}$ (0,06%)

Sample	Means ± Standard Deviation	Difference between means
Control	6,66 ± 1,70	-
$F_{2,A}$	5,23 ± 2,21	1,47*
$F_{2,B}$	4,14 ± 1,95	2,56*
$F_{2,C}$	5,22 ± 1,92	1,48*

* Significant difference (p<0,05)

Besides the addition of permeate, the perception of differences between the test samples and commercial product could have been influenced by the use of a flavor different from that of the commercial product and/or at different concentrations as well as differences in sodium content. However, there is an inherent difficulty in applying this test to the product in question: the target audience is restricted to individuals who practice physical activities, and the tasters may have had specific habits and personal characteristics that could have influenced the results of the test.

The tasters attributed a score of less than 7 to commercial sports drink (control). This may have occurred because the product is not frequently used by the individuals who participated in the evaluation, which may have also contributed to the low scores for the drink formulated with whey permeate. Thus, the enrollment of judges accustomed to the consumption of sports drinks would be valuable for comparisons of such products.

4 CONCLUSION

The preparation of an isotonic beverage with whey permeate obtained through nanofiltration proved to be an option for the use of this byproduct. As variation in minerals occurs depending on the type of cheese produced, season of the year, type of feed and the genetics of dairy cows, regular analysis and standardization of the permeate is required to obtain a formulation in compliance with legislation that also has acceptable sensory properties.

In sensory terms, the product was well evaluated in comparison to the control product, although both achieved a score below 7,0. For the sports drink prepared from whey nanofiltration permeate, it would be ideal to perform the test with a group of trained tasters accustomed with this type of drink, which could have led to higher scores for the product.

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