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Effect of Jerusalem artichoke syrup (*Helianthus tuberosus* L.) on the properties of fermented vegetable beverages

Efecto del extracto de topinambur (*Helianthus tuberosus* L.) en las propiedades de las bebidas vegetales fermentadas

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Abstract

This study aimed to evaluate the effect of prebiotics (*Jerusalem artichoke syrup and commercial inulin*) on the characteristics of *Prunus dulcis* var “*Non Pareil*” almond beverages, inoculated with probiotics (*Streptococcus salivarius* subsp. *thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*). The inulin content obtained in the Jerusalem artichoke syrup was 2.25 grams of inulin per 100 grams of total fructans, in the sample at 7°Bx. The fermented products were evaluated for physicochemical, microbiological and sensory properties during cold storage (4°C) for 28 days. The fermented beverages with the addition of Jerusalem artichoke syrup showed higher acidity (lower pH value and higher lactic acid content), and higher density than the product made with commercial inulin. The addition of Jerusalem artichoke syrup affected the textural parameters. The products showed less hardness, stickiness, gumminess and higher values of cohesiveness and elasticity than those made with commercial inulin. The sample with the highest sensory preference was the one prepared with commercial inulin and a filtered vegetable beverage. The concentration of lactic bacteria remained higher in the samples with Jerusalem artichoke syrup with the same proportion of inulin than the samples with commercial prebiotic, during 21 days of storage under refrigeration.

Keywords: Prebiotic, Jerusalem artichoke, Lactic bacteria, Inulin, Fermented beverages.

Resumen

Este estudio tuvo como objetivo evaluar efectos de prebióticos (jarabe de topinambur e inulina comercial) sobre las características de bebidas de almendras *Prunus dulcis* var “*Non Pareil*”, inoculadas con probióticos (*Streptococcus salivarius* subsp. *thermophilus* y *Lactobacillus delbrueckii* subsp. *bulgaricus*). El contenido de inulina obtenido en jarabe de topinambur fue de 2,25 gramos de inulina por 100 gramos de fructanos totales, en la muestra a 7°Bx. Se evaluaron las propiedades fisicoquímicas, microbiológicas y sensoriales de los productos fermentados durante el almacenamiento en frío (4°C) por un período de 28 días. Las bebidas adicionadas con jarabe de topinambur mostraron mayor acidez (valores menores de pH y contenidos mayores de ácido láctico) y mayores densidades que el producto elaborado con inulina comercial. La adición de jarabe de topinambur afectó los parámetros de textura, los productos mostraron menor dureza, adhesividad, gomosidad y mayores valores de cohesión y elasticidad que los elaborados con inulina comercial. La muestra con mayor preferencia sensorial fue la preparada con inulina comercial y bebida vegetal filtrada. La concentración de bacterias lácticas se mantuvo mayor en las muestras con jarabe de topinambur con la misma proporción de inulina que las muestras con prebiótico comercial, después de 21 días de almacenamiento en refrigeración.

Palabras claves: Prebiótico, Topinambur, Bacterias lácticas, Inulina, Bebidas fermentadas.

Introduction

Jerusalem artichoke (*Helianthus tuberosus* L.) is a plant of the sunflower family native to North America. It produces tubers with high yield [1], which store inulin as an energy source. The content of this fructan in the tubers varies between 8-21% [2]. Due to β (2 $\rightarrow$ 1) bonds, inulin cannot be digested by intestinal enzymes and thus it can be successfully used in the development of functional food [3]. On the other hand, it has been shown that carbohydrates rich in inulin, which are from Jerusalem artichoke tubers, favor the growth and the probiotic properties of certain strains of *Lactobacillus* [4]

In recent years, there has been a growing consumption of vegetable beverages. The reasons that lead consumers to these changes in their eating habits are diverse: increased levels of lactose intolerance, different types of diet, desire for a healthy life style, concern for animal welfare and environmental concerns. The literature has confirmed the suitability of beverages prepared from different varieties of almonds with the aim to obtain a fermented product [5]-[8].

In this work, a product based on a vegetable beverage made from almonds (*Prunus dulcis* var. 'Non Pareil') fermented with lactic acid bacteria was developed. The physicochemical and sensory properties were studied during cold storage (4°C) controlling the viability of lactic bacteria. The physicochemical analysis of the Jerusalem artichoke extract was carried out and different formulations of the fermented vegetable beverage were prepared with the addition of Jerusalem artichoke syrup and commercial inulin. Physicochemical properties were measured and a sensory study was carried out with an untrained panel that revealed the most accepted formulations, which were analyzed nutritionally.

Materials and Methods

Materials

Almonds (*Prunus dulcis* var 'Non Pareil') from Pacific Nut Company (Chile) were purchased from local businesses. The white variety of the Jerusalem artichoke tubers, which were used in this study, were manually harvested in 2016 in experimental plots of land located at the National Institute of Agricultural Technology experimental station located in City of Villa Mercedes, San Luis, Argentina.

Freshly harvested tubers were cleaned with a brush to remove the remains of soil and disinfected with a 100 mg/kg sodium hypochlorite solution to reduce the load of microorganisms on the surface finally, they were dried in a stream of air. The cleaned and dried tubers were packed

in plastic bags and stored in a chamber at 4-5°C and a relative humidity of approximately 98%, until their use. Lyophilized, thermophilic lactic cultures were purchased from AEB Argentina. The lactic acid bacteria present include *Streptococcus salivarius* subsp. *thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*, identified as Y03 (10U) in packages of 40 g for 500 L of beverage. In addition, commercial inulin (Terrium-Chile) and samples of pectin type LM-106 AS-YA, (CP-KELCO-USA) were used in the formulations. The low amidation ester pectin was obtained from citrus peel and it has been standardized by the addition of sucrose.

Preparation of the almond beverage

The methodology of Dhakal et al [9] was used for the preparation of the vegetable beverage. The almonds were soaked in tap water at 4°C for 12 h (3:1, water: almond, w/w). After the established time, the water was drained from the seeds and they were peeled manually. Using a ratio of one-part dry weight of almonds to nine parts of tap water, the mixture was processed with a 550 W blender for 3 min. Almond beverages were used for the preparation of fermented samples, both filtered and unfiltered. A muslin bag was used for the filtered samples. Pasteurization was carried out according to the requirements for cow's milk: the samples were placed in closed containers, heated to 63°C and kept at this temperature for 30 min in water bath. It was subsequently cooled to 4°C.

Preparation of the Jerusalem artichoke syrup

The tubers were peeled by mechanical treatment and then they were cut into slices of approximately 2 mm thick, using a domestic food processor. The liquid extraction was carried out with distilled water at 85°C in a thermostatic batch system with a solvent: fresh tuber ratio of 4:1 (v/w). The extraction time was 30 minutes with constant agitation. The extract was separated by successive stages of filtration with muslin cloth and filter paper. The filtrate was packed in clean containers. The solution obtained was kept refrigerated at 4°C until analysis. To carry out specific studies and increase shelf life, the 7°Bx extract was concentrated at 70°C, using vacuum distillation equipment, until a final concentration of 60°Bx. This concentrate was stored at room temperature under anaerobic conditions.

Preparation of the fermented beverage

The almond beverage was used in two different ways after crushing the grains: filtered and unfiltered. Commercial inulin and Jerusalem artichoke syrup of 60°Bx

were added as prebiotic material. The inulin content in samples were 1, 2 and 3%. Prior to the preparation of the samples, the dose of lyophilized culture to be added to the formulas was determined. The doses used were 0,08, 0.1 and 0,4 g of culture per 100 g of fermented beverage. Samples were pasteurized and inoculated at an initial concentration of $7,0 \log \text{CFU/mL}$ and placed at 40°C in an incubator at constant temperature. Fermentation was carried out for eight hours. After it, the samples were stored at 4°C for 4 weeks. Titratable acidity, pH, and microbial viability were determined after 1, 7, 14, 21 and 28 days of refrigerated storage at 4°C . The fermentation of each sample was performed in three independent experiments.

Physicochemical analyses

Physicochemical characterization of almond beverage

The pH value of the almond beverage samples was determined with a pHmeter (Mettler- Toledo-Switzerland) at room temperature. Total soluble solids concentration as °Bx was measured with a portable Abbe brand refractometer. Total acidity expressed as percentage of lactic acid, ash and water content were determined following the AOAC (Association of Analytical Communities) methodology [10]. Protein content was quantified using the Kjeldahl-Hach method following AOAC 981.10 method and a conversion factor of 5,18 was used [10]. Total lipids were estimated using the Bligh and Dyer method [12].

Physicochemical characterization of Jerusalem artichoke syrup

The relative density, $20^\circ\text{C}/20^\circ\text{C}$, was determined with a pycnometer following the AOAC 935.30 official method. The total acidity of the syrup was titrated potentiometrically with a 0,1 N NaOH solution, up to pH 8,1. The results were expressed in grams of citric acid/100 mL of sample. Total nitrogen was determined by the Kjeldahl-Hach method. The fructans present in the sample were evaluated by HPLC using the methodology detailed by Zuleta and Sambucetti [13]. The dehydrated Jerusalem artichoke extract was analyzed by FT-IR spectroscopy using a Perkin Elmer Spectrum RXI spectrometer and the samples were prepared with KBr. The UV-Vis spectroscopy technique was used to investigate the presence of tannins in the Jerusalem artichoke extract. The absorption spectrum was performed in an UV-1800 Shimadzu spectrophotometer. The samples obtained from the solid-liquid extraction were centrifuged and subsequently filtered using a membrane filter with a pore size of $1 \mu\text{m}$. Aliquots of 1 mL were taken and placed in polypropylene cells of 1 cm.

Physicochemical characterization of the fermented beverage

Total acidity and pH were determined following the methodology described in the previous section.

Texture

To observe the texture of the different prepared samples, texture profile analyzes were carried out using a Brookfield PRO CT texturometer. The samples were analyzed after being cooled post-incubation in a refrigerator (4°C). All samples were contained in identical glass containers, since the use of different containers would modify the results obtained. The Texturometer was connected to a computer that documented the data through software called TexturePro CT 1.8. Results of Hardness ($g^{\rightarrow}$), % Deformation according to Hardness, Adhesiveness (mJ), Resilience, Fracturability ($g^{\rightarrow}$), Cohesiveness, Elasticity Index, Rubberiness ($g^{\rightarrow}$) and Masticability Index ($g^{\rightarrow}$) were obtained.

Microbiologic analyses

Control in the vegetable beverage

The average count of fungi and yeasts was performed on samples of pasteurized and unpasteurized beverages, in the laboratory of the National Institute of Technological Research (INTI-San Luis). The count of fungi and yeasts was carried out according to “Yeasts, molds and mycotoxins” of the Microbiological Manual of the FDA [14]. The average count of lactic acid bacteria was carried out using MRS agar, in the INTI laboratories, according to chapter 19 of the Compendiums of methods for the microbiological examination of foods.

Determination of viable bacterial cells in fermented beverage

Viable cells were determined using the standard plate count method. Cells were incubated at 37°C for 48- 72 h with MRS agar medium and expressed as colony-forming units per milliliter of sample (CFU/mL). The titratable acidity and the pH were measured to reveal changes in acid content at sampling points. The pH values of the fermented beverage samples were measured using a digital pHmeter (Mettler Toledo, Ohio, USA). Titratable acidity values were determined according to the ISO standard procedures.

Sensory evaluation

The twelve samples were tested by a small trained panel to select four of them: two with commercial inulin, and the other two with Jerusalem artichoke syrup at 60° .

Sensory analysis was carried out to assess differences in the fermented beverage samples by 30 untrained panelists using a 9-point hedonic scale. The ages of the

panelists ranged from 20 to 35 years. The panelists were recruited from students of the School of Engineering and Agricultural Sciences of the National University of San Luis. Thirty panelists (12 men and 18 women) were divided into 3 groups: 12 panelists aged between 20 and 24 years; 13 panelists aged between 25 and 30 years, and 5 panelists aged between 31 and 35 years. Specific indicators, i.e., sweetness, sourness, bitterness, flavor, sour aroma, texture and general acceptability were estimated. Samples were rated using the words “low” (1- 3), “medium” (4- 6), and “high” (7- 9), being 1 “poor” and 9 “excellent”. Each panelist received 4 samples of 20 g each to be analyzed in pairs in small plastic cups coded with three digits. Sensory evaluation was carried out in individual booths. The fermented beverage was served in three-digit coded paper cups. Panelists used water to rinse their palates between samples. The preferred samples emerged from this test, one with commercial inulin and filtered vegetable beverage and the other with inulin-rich extract and filtered vegetable beverage. A shelf life and Nutritional Analysis study will be carried out on the samples chosen by the sensory panel.

Results and Discussion

Characterization of the almond beverage and shelf life study

Table 1 shows the results of the physicochemical and microbiological analyses performed on the non-heat-treated and pasteurized almond beverage (values in parentheses).

Table 1: Physicochemical and microbiological properties of the unpasteurized and pasteurized almond beverage.

Property	Unpasteurized beverage (pasteurized beverage)
pH (25°C)	6,44±0,02 (6,39±0,01)
Brix	5,60±0,00 (5,50±0,01)
Lactic acid, % (w/w)	0,05±0,01
Ashes, % (w/w)	0,26±0,01
Water, % (w/w)	92,71±0,02
Proteins, % (w/w)	1,95±0,03
Fat matter, % (w/w)	4,98±0,02
Protein nitrogen, % (w/w)	10,09±0,03
Density (25°C)	1,00 g/cm ³
Average count of lactic bacteria and yeasts	2,25×10 ⁴ CFU/mL (4,35×10 ³ CFU/mL)
Average count of fungi and yeasts	5,35×10 ³ CFU/mL (7,85×10 ² CFU/mL)

Studies of the thermal effect on the almond beverage stability have shown that above 55°C, the hydrophobicity of the protein surface and the size of the particles increase, reducing the stability of the whole and the skimmed beverage. This would explain the behavior observed during the shelf-life study. The freshly pasteurized samples showed phase separation, with an upper layer formed by a

fine and shifting powder. The samples under refrigeration (pasteurized and unpasteurized) maintained their constant conditions until the third day of control [15].

The samples stored at 25°C in a stove were highly affected by the storage condition. A loss of the characteristic aroma of the freshly brewed beverage was detected. The pH was little affected by the storage temperature and a decrease to 6,33±0,01 and 6,29±0,01 was observed for treated and raw samples, respectively. On the third day, a more pronounced decrease in pH was observed in the stove samples and their odor was altered.

Physicochemical characterization of Jerusalem artichoke syrup

Table 2 shows the physicochemical properties of the Jerusalem artichoke syrup used in this work. The experimental results show that the aqueous solution obtained from the solid-liquid extraction process is slightly acidic and light brownish; it has a pleasant odor and a slightly sweet taste. The concentration of soluble solids, at the end of the process, was 7°Bx. In 2021, Redondo-Cuenca *et al.* studied the effect of the variables such as temperature, substrate/solvent ratio and operation time on the extraction of Jerusalem artichoke inulin, showing a maximum value of (inulin+ fructo-oligosaccharides) of 81,4 g/100 g dry weight at 62,4°C; 21,7 minutes and a solvent/dry solid ratio of 32,3. In this work, solid-liquid extraction was carried out at 85°C and a solvent/dry solid ratio of 4:1, obtaining a lower yield (45%), expressed as g inulin/solvent volume x dry Jerusalem artichoke mass. This decrease can be explained by the operating conditions of the solid-liquid system, since the process was carried out at the pilot plant level, which implied a greater number of tubers to be processed per batch, and a less efficient level of solid-liquid contact. The higher operating temperature used, compared to the mentioned studies, could have caused the hydrolysis of the glycoside bonds in inulin, contributing to the decrease in yield [16].

Table 2: Physicochemical properties of Jerusalem artichoke extract.

Property	Value
pH (25°C)	6,48±0,01
°Bx	7,00±0,03
Conductivity, µS/cm (20°C)	824,00±0,03
Ashes (g/100 mL of sample)	0,60±0,01
Dry residue, g/L	48,84±0,01
Total nitrogen, % (w/w)	4,38±0,1
Relative density (20°C)	1,02±0,02
Acidity (% citric acid)	0,04±0,03

The nitrogenous species present in the solution represent a low value as estimated by the Kjeldahl-Hach method, as well as the mineral content. No appreciable lipid values were obtained.

HPLC Analysis

The chromatogram of the Jerusalem artichoke extract of 7°Bx showed characteristic peaks assigned to fructans. The profile found (not shown here) and the results of the quantitative analysis allowed determining an inulin concentration of 2,25 g/100 g of total fructans in the sample at 7°Bx. The inulin peak corresponds to a retention time of 6,7 minutes for the program used. In addition, compounds from the inulin hydrolysis were observed; this is due to the high extraction temperature and the acid medium that favors the inulin hydrolysis. These similar behaviors were also observed in the literature [17]. In 2012, Bach *et al.* reported that the time and temperature of the tubers storage condition the degree of polymerization of fructans and the inulin chains can hidrolize into shorter-chain polymers during hibernation. In the initial stages, the tubers have a higher content of polymerized fractions and as the storage time elapses, the enzymatic activity causes the hydrolysis of the inulin molecules to fructo-oligosaccharides, sucrose and fructose. In this work, tubers stored for 6 months since their harvest were used.

FTIR spectroscopy

Figure 1 shows the FTIR spectra of commercial inulin powder and of the dry Jerusalem artichoke extract sample. The spectra can be divided into four characteristic regions, from 3600 to 2500 cm^{-1} , 2500 to 1550 cm^{-1} , 1500 to 900 cm^{-1} and values below 900 cm^{-1} . At around 3300 cm^{-1} a broad band due to the bond vibration of the O-H groups (hydroxyl stretching) can be seen. In the region between 3000 and 2700 cm^{-1} a sharp band of medium intensity approximately at 2930 cm^{-1} , which is assigned to the asymmetric C-H stretching of the methylene groups (CH_2) and a barely perceptible shoulder at 2890 cm^{-1} , which maps with the symmetric stretching of the same group are also showed. In the second region, the stretching band of the carbonyl group, due to the open structures in equilibrium with the hemiacetal forms of glucose and mannose is showed. This band is pronounced in the Jerusalem artichoke extract sample, as this is a natural product without refinement containing, in addition to free fructose, free glucose and free mannose, but also attributable to carbonyl groups of amide or peptide bonds of proteins that are also extracted in aqueous medium.

In addition, in the commercial sample the signal is of low intensity, indicating the presence of the mentioned compounds only in traces. Wu and Lee [18] reported in FTIR analysis of inulin that characteristic bands associated with OH groups were found at 3353 cm^{-1} and C=O at 1745 cm^{-1} . In both spectra of Figure 1, bands at 3378 cm^{-1} are assigned to OH groups.

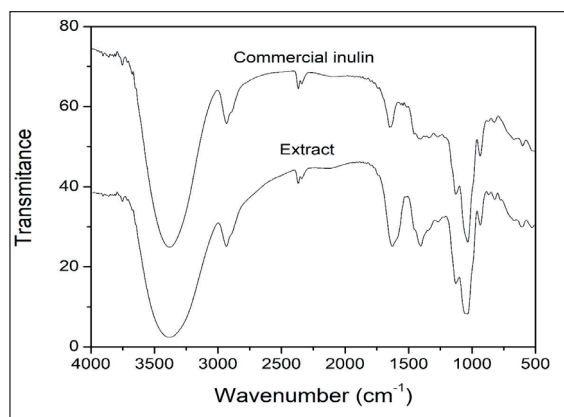


Fig. 1: FTIR spectra for commercial inulin and extract.

The spectral region between 1500 and 900 cm^{-1} is dominated by the complex sequence of intense bands mainly due to the strong couplings of the C-C, C-O stretches and the C-O-H and C-O-C deformation modes of various oligo and polysaccharides. In this region, bands at 1330 and 1400 cm^{-1} were attributed to the bending vibrations in the plane of CH , CH_2 and the O-H groups of the fructose ring, where the first signal corresponds to the symmetric deformations and the second signal to the asymmetric ones. At 1030 and 1130 cm^{-1} , the stretching bands of C-O and C-O-C and the annular modes of vibration of cyclic structures were observed. In Figure 1, signals are recorded at 933 cm^{-1} , which were assigned to inulin by Bekers *et al.* [19]. In the last region, at lower wavenumbers of 900 cm^{-1} , a variety of characteristic bands that are very useful for the conformational study of carbohydrates were observed. The bands at 670, 650 and 590 cm^{-1} indicate the presence of pyranose rings.

The difference between commercial inulin and that extracted in the form of syrup appears in the area of 800 to 600 cm^{-1} , where the variation is notable due to the presence of glucose, sucrose and mannose [20]. Peaks assigned to compounds from inulin hydrolysis such as glucose had also been found in HPLC chromatography studies.

UV-Vis spectroscopy

A study on the presence of tannins in Jerusalem artichoke reported that Jerusalem artichoke tuber contains phenolic compounds as bioactive constituents [21]. On the other hand, Seljasen *et al.* found that the Jerusalem artichoke peel has high amounts of phenolic compounds with a high antioxidant capacity [22]. However, their concentration in the tuber pulp is low and without antioxidant activity. The analysis of the absorption spectrum of the Jerusalem artichoke extract sample at 7°Bx is carried out in the band between 247 and 351 nm, which presents low absorbance intensity. From these results, it can be inferred that the syrup contains a low concentration of tannins that absorb in the area of less intensity for these chromophores, and their presence could be justified especially by the presence of shell remains from the peeling stage.

Physicochemical characterization of the fermented beverage

Different formulas were tested with the raw materials to obtain a healthy product with a consistency similar to yogurt. In total there were 12 formulations in which half used filtered vegetable drink, commercial inulin in different concentrations and pectin.

The other half used unfiltered vegetable drink, Jerusalem artichoke extract in quantities that had the same amount of inulin as the previous ones, and pectin. The pH values of the fermented beverage without the addition of Jerusalem artichoke are slightly higher than those reported in the literature using only commercial inulin [23]. The samples with syrup have higher values of acidity, expressed in terms of percentage of lactic acid. These values are higher than those informed for products developed with probiotics and inulin. The density increases linearly with the concentration of inulin for the samples that contained commercial inulin and filtered vegetable beverage. In the samples with Jerusalem artichoke extract, both the absolute values and the slope of the trend line were higher.

The samples prepared with filtered vegetable beverage showed syneresis and the fermented phase separated in a layer of 1 cm thickness on average.

The addition of extract to the samples did not improve syneresis. In the present work, the addition of 0,5 g/100 g pectin to all samples, improved the consistency even though the product continued to have two very visible phases. The samples presented better organoleptic characteristics when the unfiltered almond beverage with amidated pectin was used. The fermented samples obtained in these cases were homogeneous, with little syneresis, good consistency and appearance.

Textural Analysis

Hardness or firmness is a critical parameter for evaluating the textural characteristics of foods. Also, it is the most commonly evaluated parameter for yogurt texture analysis and was defined as the force required to achieve a given deformation.

This factor is a critical textural property for yogurt-like products. Products with commercial inulin showed greater hardness than those made with Jerusalem artichoke extract. Some studies have shown that the addition of functional components in yogurts causes a decrease in hardness. This could be observed in yoghurts with the addition of olive, onion, citrus and garlic extracts, where a decrease in hardness or firmness was observed [24].

The adhesiveness or stickiness of the samples sensorially represents the work required to detach the product from the palate. This property has an inverse relationship with the quality of the fermented products. The lowest value of adhesiveness was for the most concentrated sample in syrup extract and filtered beverage and the

highest value for the sample with commercial inulin and unfiltered beverage.

Cohesiveness represents the bond strength in the sample, which can be deformed to the breaking point. The lowest values were recorded for samples with commercial inulin and the highest for samples with high syrup concentrations. The elasticity index is the recovery property of the food, where the value 1 indicates that the material is completely elastic and the value 0 indicates that the material is completely viscous. The elasticity property depends on various factors such as heat treatment, protein interaction, and degree of protein unfolding. The samples showed high values of elasticity index between 0,90 - 0,98, as in light commercial yoghurts from the local market. Mousavi *et al.* defined the force to break down a food into fragments to be swallowed is called gumminess, and it has an undesirable effect on appearance and texture. It can be seen that the samples with Jerusalem artichoke syrup had similar gumminess values and their values are lower than the samples containing commercial inulin.

Sensory analysis

The selection was based on distinguishable characteristics such as texture and consistency, to be tested by an untrained panel. From this test, the most preferred sample emerged, one of them with commercial inulin and filtered vegetable beverage and the other with inulin-rich extract and filtered vegetable beverage, as shown in Fig.3 y Fig. 4.

A shelf life and Nutritional Analysis study will be carried out on the samples chosen by the sensory panel.

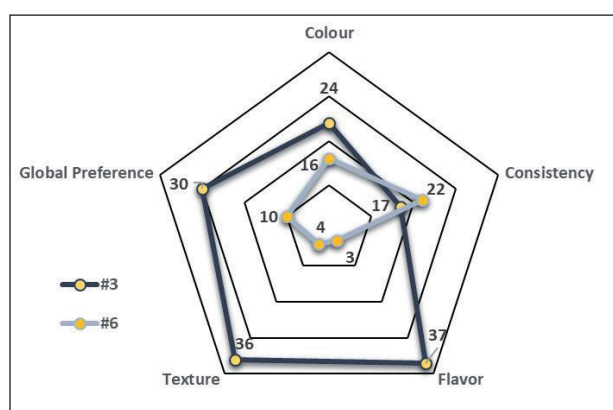


Fig. 2: Sensory Panel result between sample with inulin and filtered vegetable drink (#3) and sample with extract and filtered vegetable drink (#6).

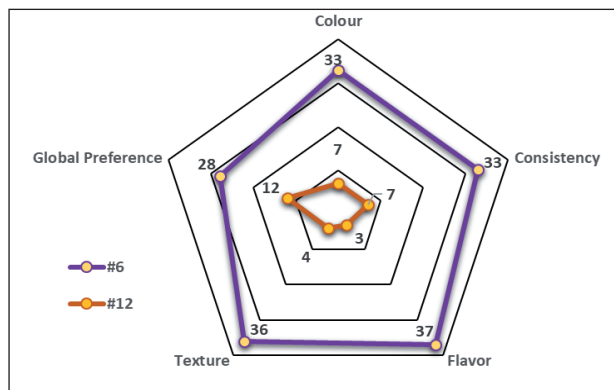


Fig. 3: Sensory Panel result between sample with inulin and non-filtered vegetable drink (#9) and sample with extract and non-filtered vegetable drink (#12).

Shelf Life and Nutritional Analysis

The viability of lactic acid bacteria decreases as the study progresses, maintaining the necessary viability during the shelf life of 10 days at 4°C. The concentration of lactic acid bacteria was higher in the sample with Jerusalem artichoke extract with the same proportion of inulin than in the sample with commercial prebiotic. A greater difference in viability was observed after the first day of analysis and from day 21 onwards this difference decreases with an asymptotic trend at the end of the study.

Table 3: pH variation during storage.

Formula	pH (T°)				
	Day 1	Day 7	Day 14	Day 21	Day 28
#3	4,69 ± 0,02 (8,71°C)	4,48 ± 0,06 (8,37°C)	4,2 ± 0,06 (8,51°C)	4,12 ± 0,05 (8,37°C)	3,91 ± 0,04 (8,82°C)
#9	4,97 ± 0,08 (9,11°C)	4,87 ± 0,03 (8,35°C)	4,85 ± 0,06 (8,42°C)	4,76 ± 0,03 (8,53°C)	4,69 ± 0,06 (8,02°C)

In 2015 Bernat *et al* showed how the viability of probiotic cultures in almond vegetable matrices, stored under refrigeration at 4°C, decreased with storage time, especially *Streptococcus*. This could be due to the increase in the concentration of organic acids, as lactic acid. *Lactobacillus* also has a decrease during its shelf life, Fig. 4. This behavior can be attributed to the need for growth factors such as amino acids and peptides, products of the proteolytic activity of some bacteria. That is the reason why the survival of *Lactobacillus* in the presence of bacteria such as *L. paracasei ssp. tolerans* increased. From the analysis of the organoleptic characteristics during storage, it was observed that there is a decrease in flavor from day 21, being more noticeable in the samples with inulin. The taste is mainly weakened in the samples with extract compared to the fresh sample. The consistency of both formulas was not affected during storage.

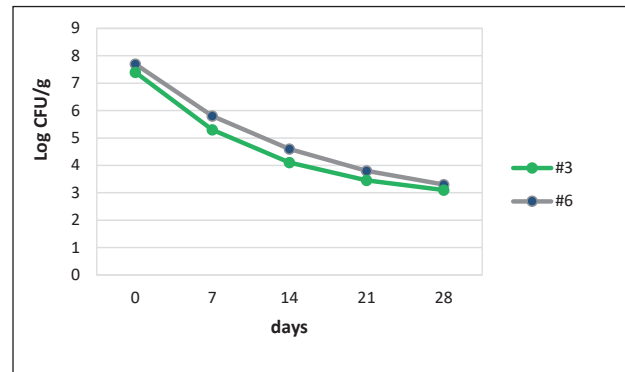


Fig. 4: Feasibility analysis for BAL for 28 days.

Finally, the nutritional analysis on the samples selected in the acceptability tests were performed. Table 4 shows the nutritional information of the two-fermented beverage.

Table 4: Nutritional information in 100g of fermented beverage with inulin (BI), and Jerusalem artichoke (BJ).

Energy/Nutrient	In 100g of the product	
	BI	BJ
Energy (Kcal)	28,0	63,0
Carbohydrates (g)	0,8	6,6
Total fat (g)	2,0	3,0
Fiber (g)	2,7	2,6
Ca (mg)	71	52
Na (mg)	78	88

It was possible to determine that the formula with extract provides more than twice the energy than the sample with commercial inulin and its value is similar to the energy value of a low-fat yoghurt.

The carbohydrate value of the sample with syrup and filtered beverage triples the declared value for the sample with inulin and filtered beverage and is similar to the value of low-fat commercial yoghurt.

The values of proteins and fats are also higher, although the difference between the two samples is smaller.

The dietary fiber values were very similar, considering that the inulin content in the syrup is equal to the dose of commercial inulin added to the sample.

This could be since part of the almond beverage was replaced with extract. On the other hand, it is proven that the consumption of Jerusalem artichoke helps the absorption of calcium and iron and, together with inulin, reduces cholesterol and triglyceride levels [25].

Conclusions

The results of this work show that the syrup obtained from the Jerusalem artichoke tubers have prebiotic properties since they favor the multiplication of probiotic bacteria, maintaining the necessary viability during the shelf life of 10 days at 4°C. The intense acidification of beverages with Jerusalem artichoke extract can be

a limiting factor in shelf life at 4°C. It was possible to determine that the formula with Jerusalem artichoke syrup provides more than twice the energy than the sample with commercial inulin and its value is similar to the energy value of low-fat yoghurt, due to the high concentration of fructooligosaccharides. Fermented almond beverages with the addition of Jerusalem artichoke extract can be an alternative to the consumption of non-dairy products by vegans and people with lactose intolerance or allergy to milk proteins.

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