POTENTIAL OF QUINOA FOR PRODUCTION OF NEW NON-DAIRY BEVERAGES WITH REDUCED GLYCEMIC INDEX

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ARTICLE INFO

Regular article

Published 1. 6. 2023

Received 10. 2. 2023

Revised 21. 4. 2023

Accepted 9. 5. 2023

ABSTRACT

Recently, there has been a growing effort to include underutilised crops to food products. The potential of pseudocereal quinoa for the production of non-dairy plant-based beverages was investigated. Developed products were analyzed for nutritional composition, sugars, glycemic index, technological parameters, and sensory acceptance in comparison with a commercial quinoa beverage. Quinoa beverages contained 0.60-0.63 g per 100 mL proteins, had a medium glycemic index and their energy values ranged from 113.14 to 120.79 kJ per 100 mL of beverage. For improvement sensory acceptance of beverages, these were sweetened with natural sweeteners with a low glycemic index (inulin or agave syrup). It was found that the final products had similar consistency as commercial quinoa drink, but showed a lower overall acceptance. Moreover, it was determined that the acceptance of beverages sweetened with agave syrup was higher than those sweetened with inulin. Due to the absence of gluten in quinoa and medium glycemic index of final products, the developed beverages can represent a new alternative for consumers with special nutritional needs. The addition of suitable ingredients may be recommended to improve their acceptance.

Keywords: quinoa, glycemic index, beverages, sensory evaluation, nutritional composition

INTRODUCTION

In the last decades, considerable attention of researchers was orientated to inclusion of underutilised grains and pseudocereals (starch-rich grains, but dicotyledons) to different types of foods and beverages (Vega-Gálvez et al., 2010; Kaur and Tanwar, 2016; Urquizo et al., 2017; Lorriso et al., 2018). Quinoa (Chenopodium quinoa) is an ancient crop originated in the Andean region of South America that is known for its nutritional and health benefits (Zammini et al., 2018). Quinoa is a rich source of protein (12-20%), as its protein level is remarkably higher than in common cereals (Väkeväinen et al., 2020). The globulins (37%) and albumsins (35%) are the major proteins found in quinoa, while prolamins are present in a low percentage (0.5–7.0%) (Dakhili et al., 2019). Due to this fact, the consumption of quinoa and quinoa derived products is recommended for celiac disease patients (Areggian et al., 2022). Moreover, the proteins of this pseudocereal contain a high amount of essential amino acids, such as lysine (5.1–6.4%) (limiting amino acid in some grains and wheat), methionine, and threonine (Urquizo et al., 2017; Aguilar et al., 2019; Sezgin and Sanlier, 2019). According to FAO/WHO recommendations, quinoa protein can supply over 100% of the daily recommended intake of essential amino acids for adult nutrition (Graf et al., 2015). Quinoa seeds also contain significantly higher amounts of minerals (calcium, magnesium, iron, and zinc) and some vitamins (E, B group, and C) than common cereals (Aguilar et al., 2018; Zammini et al., 2018). The main carbohydrate present in quinoa is starch (52-60%). Content of total dietary fibre in quinoa varied from 2.6 to 10% with about 78% of its fibre content being insoluble and 22% soluble (Bastidas et al., 2016; Navruz-Variš and Sanlier, 2016; Montemurro et al., 2019). Moreover, this crop contains about 3% of sugars, represented by high levels of D-xylose and maltose, a low amount of glucose and fructose (Graf et al., 2015; Gordillo-Bastidas et al., 2016; Navruz-Variš and Sanlier, 2016; Ahmed et al., 2019). The lipid content of quinoa ranges from 2 to 9.5%, which is a higher amount, as determined in maize (3-4%). The most abundant fatty acids are polyunsaturated fatty acids such as linoleic and alpha-linolenic acids (Bastidas et al., 2016; Navruz-Variš and Sanlier, 2016; Montemurro et al., 2019). Quinoa is also an excellent source of phytosterols, lipophilic compounds with hypocholesterolemic effects, among which β-sitosterol is present in the highest amount (Navruz-Variš and Sanlier, 2016; Montemurro et al., 2019).

Quinoa is also considered as a food with a low glycemic index (35-53, depending on the processing) (Vega-Gálvez et al., 2010; Srujana et al., 2017) with slow glucose release into the bloodstream after intake (Lopes et al., 2019). Erfidan et al. (2022) described, that the consumption of quinoa is supposed to be beneficial in diabetes and associated hypertension. It was shown that intake of this pseudocereal significantly lowers blood sugar and increase the glucose tolerance in diabetic patients (Gabrial et al., 2016). Graf et al. (2015) demonstrated that 20-hydroxyecdysone, the most abundant quinoa phytoecdysteroid, is responsible for the anti diabetic effect of these crops. In recent years, interest in plant-based beverages derived from different crops has been increasing worldwide (Jeske et al., 2017; Fernandez et al., 2018; Fructuoso et al., 2021; Pointic et al., 2022). On the other hand, only limited studies related to quinoa-based drinks are available (Pinelli et al., 2015; Kaur and Tanwar, 2016; Urquizo et al., 2017; Sruthy et al., 2021). Due to the nutritional facts mentioned above, quinoa can have a great potential for production beverages with added value. The aim of this study was to assess the potential of underutilised pseudocereal quinoa for the production of gluten free beverages. The nutritional composition, physicochemical properties, and sensory acceptance of beverages were also determined.

MATERIAL AND METHODS

Raw materials

Quinoa seeds (dmBio, dm-drogerie markt GmbH, Karlsruhe, Germany), sunflower oil (Věnusz, Bunge Zrt., Budapest, Hungary), lecithin (Adelle Davis, s.r.o., Bratislava, Slovakia), xanthan gum (Vega Provita, s.r.o., Frýdek Místek, Czech Republic), inulin (FandN, s.r.o., Tišice, Czech Republic) and agave syrup (dnBio, dm-drogerie markt GmbH, Karlsruhe, Germany) were purchased from local markets in Slovakia. Bacterial alpha amylase (Termayl SC DC, Novozymes, Denmark) was applied to starch hydrolysis in the samples.
Quinoa pretreatment

Before using quinoa seeds for beverages preparation, they were treated by desaponification, drying (at 60°C for 8 hours) and grinding according to the procedure that was previously reported by Urquizon et al. (2017).

Preparation of beverages

The procedure was adopted from Pineli et al. (2015) with several modifications. Pretreated seeds were mixed with water (12.5% quinoa in the mixture). The mixture was cooked for 30 minutes (gelatinization of starch) and cooled to 80°C. Subsequently, heat-stable bacterial alpha amylase (Termamyl SC DC, Novozymes) was added (calculated to 2 mL/kg of starch) and the mixture was heated at 80-85°C for 60 min, after that the enzyme was inactivated by boiling (15 min). The product was cooled to 40°C and filtered through gauze and then sunflower oil (0.8%, v/v) and lecithin (0.03%, w/v) were added. In the next step, four types of beverages (A–D) were formulated by adding the following ingredients in different combinations: xanthan gum (0.5%, w/v), inulin (3%, w/v), agave syrup (3%, v/v). The ingredients included in the individual beverages are presented in Table 1. Beverages were stored at 5°C.

Table 1 Additional ingredients incorporated to beverages

<table>
<thead>
<tr>
<th>Beverage</th>
<th>Beverage</th>
<th>Beverage</th>
<th>Beverage</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>Lecithin</td>
<td>Lecithin</td>
<td>Lecithin</td>
<td>Lecithin</td>
</tr>
<tr>
<td>Sunflower oil</td>
<td>Sunflower Oil</td>
<td>Sunflower Oil</td>
<td>Sunflower Oil</td>
</tr>
<tr>
<td>Xanthan gum</td>
<td>Xanthan gum</td>
<td>Inulin</td>
<td>Agave syrup</td>
</tr>
</tbody>
</table>

Proximate composition and glycemic index

The fat, moisture, ash, and starch were determined according to methods described by Moreels and Amylum (1987) and Sowbhagya et al. (2007). Nitrogen content was estimated by the Kjeldhal method and converted to protein using a factor of 6.25 (Ayadi et al., 2009). A digital pH meter (inoLab pH Level 2; WTW, Weilheim, Germany) was applied to pH determination. Total carbohydrates were calculated by difference (100% minus the contents of water, protein, fat, and ash) (Raczkowska et al., 2019). Saponin content was measured by method adopted from Koziol (1991). The energy values of the samples were calculated using conversion factors reported by Onoja et al. (2014) (% protein × 4 + % carbohydrates × 4 + % fat × 9 kcal). Sugars (glucose, fructose and maltose) were determined by HPLC with RI detector according to methods of Kojadová et al. (2009) and Magala et al. (2015). Glycemic index (GI) of beverages was calculated according to GI prediction model described by Ritz et al. (2019).

Colour of beverages

The colour measurements were realised by Spectrophotometer Cary 300 (UV–VIS Agilent Technologies, Santa Clara, USA). Colour values were determined using the CIELAB colour system with reference to the illuminant D65 and a visual angle of 10°. The colour of the beverages was characterised as the whiteness index (WI) and was calculated according to the equation reported by Milovanovic et al. (2020).

Technological properties of beverages

Water holding capacity (WHC) of beverages was measured according to centrifugation method described by Zanmini et al. (2018). The viscosity of beverages was determined using a rotation viscometer (Haake VT 550, Haake Mess –Technic, Germany) (Magala et al., 2015). Serum separation was measured by procedure of Koskoy and Kilic (2004).

Sensory evaluation of beverages

Sensory attributes of beverages were evaluated by panel assessors (11 – member panel) using a 9 –points hedonic scale (1 – dislike extremely; 9 - like extremely) (Walsh et al., 2014). Assessors evaluated taste, odour, colour, and consistency of prepared products. The overall acceptance of beverages was assessed by using 100 mm graphical unstructured line segments with specified end-points (Karovilová et al., 2020). The commercially available quinoa drink in the local Slovak market was used as a reference beverage (unflavored drink, Organic La Famiglia organic, Italy) (composed of spring water, organic quinoa, rice, sunflower oil, safflower oil, and sea salt).

Statistical analysis

All experimental analyses were carried out using three independent determinations and expressed as the mean value ± standard deviation. Statistical analyses were performed using Microsoft Excel (Microsoft Corp., Redmond, WA, USA) with XLSTAT for MS Excel Addinsoft SARL, Paris, France. A Pearson correlation analysis was applied to find the relationship between nutritional composition and glycemic properties of beverages. Analysis of variance was used to describe the significance differences (p<0.05) between the nutritional composition, technological properties, and sensory attributes of commercially produced and developed quinoa beverages.

RESULTS AND DISCUSSION

Formulation of quinoa-based beverages

Quinoa pericarp can contain bitter compounds saponins at levels up to 5% depending on the variety (Urquizon et al., 2017). For removing these substances, processing of seeds by peeling, washing or water maceration is necessary (Vega-Galvez et al., 2010; Pineli et al., 2015; Urquizon et al., 2017). The studied quinoa cultivar “Oblubník” contained 0.38 ± 0.05% saponins. The next step was to increase the solubility of the seeds to non- detectable level by repeated intensively washing with tap water. Several authors documented that pseudocereals contain large amounts of starch and when heated above gelatinization temperature (55–65°C), they form a viscous paste (Tano-Debrab et al., 2005; Pineli et al., 2015; Silva et al., 2020). Due to this fact, alpha amylase was added to the mixture to liquefaction of gelatinized starch. Content of starch before the application of the enzyme in the studied mixture represented 5.75 ± 0.23 g per 100 mL, due to starch hydrolysis, the starch content in the final beverages was significantly reduced (11.13-11.82 times lower content than in the original mixture). Previously, it was stated that higher GI of some plant-based beverages may be due to the presence of starch, which leads to the release of glucose during digestion (Shikembí and Huppers, 2021). Different ingredients can be added to plant-based beverages to improve their nutritional value, functional or sensory attributes (Mc Clements et al., 2019; Ayzar et al., 2020; Fructuoso et al., 2021). According to Fructuoso et al. (2021), the addition of vegetable oils to plant-based beverages can provide a smooth mouthfeel similar to that of cow’s milk. Ayzar et al. (2020) and Pineli et al. (2015) documented that the addition of sunflower oil to these types of beverages can improve the silky appearance of the final products. Due to these recommendations, sunflower oil was added to prepared beverages. Another ingredient added to the products was lecithin. This substance was applied as an emulsifying agent and also to improve the physical stability of beverages as was previously described by Ayzar et al. (2020). Beverages A and B were also incorporated with xanthan gum. This ingredient has been reported as successful hydrocolloid for textural stabilisation of beverages (Kaur and Tanwar, 2016). Finally, the beverages were sweetened by inulin (beverages A and C) or agave syrup (beverages B and D). In recent years, these substances have become popular as natural substitutes for common sweeteners (such as sucrose or honey) with low GI (5-14 and 10-27, respectively) (Ozuna and Franco-Robles, 2022; Mudannayake et al., 2022; Saravia et al., 2022). Besides that, inulin belongs to the class of dietary fibre known as fructan and is often applied in processed foods for its nutritional and therapeutic benefits (Ahmed and Rashid, 2019; Rungraeng et al., 2022). The concentration of added inulin was selected according to nutritional and health claims made on foods defined as a source of fibre (Kuchtová et al., 2018).

Composition of beverages and their glycemic index

Nutritional composition of quinoa-based beverages is presented in Table 2. Beverages prepared in this study contained 0.60-0.63 g per 100 mL of proteins. Tangyu et al. (2019) documented that most commercial plant-based drinks contain little or even no protein (< 0.50 g per 100 mL). Values obtained from this study were higher than was previously determined by Jeske et al. (2017) in commercially produced quinoa drink (0.22 g per 100 mL) but similar to those measured by Kaur and Tanwar (2016) in experimentally prepared quinoa beverages (0.68 g per 100 mL). On the other hand, a significantly higher protein content (1.23 g per 100 mL) was detected in the commercial quinoa drink presented in this study. Previously, Pineli et al. (2015) described that the application of a saline solution with 0.03 mol/L of NaCl acidified to pH 5 resulted in the highest protein yield in the final quinoa product. The pretreatment of seeds by the malting process can also be a useful method to increase the level of proteins in beverages (Kaur and Tanwar, 2016). Quinoa beverages showed a fat and ash content comparable to quinoa drinks developed by Bianchi et al. (2014) and Kaur and Tanwar (2016). On the other hand, a significantly higher fat content was determined in the commercial quinoa drink (0.52 g per 100 mL). This could be related to the fact that the commercial product contained additional ingredients such as sunflower and safflower oil. Furthermore, it was observed that the developed beverages contained significantly lower amounts of total carbohydrates than the commercial drink, which was also reflected by lower energy value of the products. Sugar composition and GI of studied beverages are presented in Table 3. Prepared beverages were sweetened with sweeteners (inulin or agave syrup) that contributed to their sugar content in the products. It was found that beverages B and D sweetened with agave syrup contained a significantly higher amount of fructose compared to other beverages. Fructose represents a sugar that is present in a high amount in processed foods (approximately 0.85% sapothex). These compounds were removed from maitose in developed beverages varied between 1.35 and 1.45 g per 100 mL. During beverage processing, alpha amylase was applied to the starch liquefaction.
These enzymes catalyse starch hydrolysis to dextrins, oligosaccharides, maltose, and glucose (Presečki et al., 2013) and thus products of starch hydrolysis can represent another source of sugar in the beverages (Jeske et al., 2017). Moreover, it was found that the commercial drink contained significantly higher amounts of glucose and maltose than experimentally prepared samples. It was found that the commercial product could be originated from the ingredients (quinoa and rice). Previously, it was documented that plant drinks prepared from the ingredients which are rich source of starch, contains higher amount of maltose and glucose (Jeske et al., 2017). This fact was also confirmed in this study.

GI is applied to demonstrate the ability of foods to increase blood glucose. This parameter is considered a very important characteristic of novel foods and beverages (Di Cairano et al., 2022). GI of beverages was calculated based on the model for prediction of GI including common glycomic carbohydrates and non-glycomic nutrients (Rhys et al., 2019). GI of prepared beverages varied between 62.78 and 68.97. Foods can be classified according to their GI into three categories: foods with low GI (< 55), medium (56-69), or high (≥70) GI (Di Cairano et al., 2022). All laboratory prepared beverages can be categorised as medium GI products.

Previously, Pineli et al. (2015) prepared experimental unsweetened quinoa drink with increased content of proteins and low GI (52). These authors documented that a higher amount of proteins may have contributed, in part, to its lower GI. On the contrary, Shkembi and Huppertz (2023) described that the higher GI of plant derived drink may be due to the presence of starch, which leads to the release of glucose during digestion. A Pearson correlation analysis was applied to find the relationship between the nutritional composition and glycemic properties of studied beverages. Strong negative correlations were observed between GI and content of glucose (r=-0.982) and fructose (r=-0.997). On the other hand, positive correlations were found between GI and the starch and ash content (r=0.867 and r=0.877). Wills et al. (1998) documented that mono and disaccharides, glucose and fructose, and total minerals are considered as nutrients with the strongest correlations with GI, this fact was also confirmed in this study. Moreover, strong correlations were found between energy value and protein (r=0.962) and total carbohydrates (r=0.852) and between starch and glucose content (r=0.922).

### Table 2 Nutritional composition of quinoa-based beverages

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Commercial drink</th>
<th>Beverage A</th>
<th>Beverage B</th>
<th>Beverage C</th>
<th>Beverage D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (g per 100 mL)</td>
<td>86.23 ± 0.19</td>
<td>93.82 ± 0.09*</td>
<td>93.39 ± 0.23*</td>
<td>93.44 ± 0.35*</td>
<td>93.69 ± 0.15*</td>
</tr>
<tr>
<td>Protein (g per 100 mL)</td>
<td>1.23 ± 0.02</td>
<td>0.63 ± 0.01*</td>
<td>0.60 ± 0.04*</td>
<td>0.61 ± 0.02*</td>
<td>0.63 ± 0.01*</td>
</tr>
<tr>
<td>Fat (g per 100 mL)</td>
<td>1.52 ± 0.02</td>
<td>0.72 ± 0.04*</td>
<td>0.71 ± 0.03*</td>
<td>0.69 ± 0.04*</td>
<td>0.60 ± 0.03*</td>
</tr>
<tr>
<td>Ash (g per 100 mL)</td>
<td>0.21 ± 0.04</td>
<td>0.33 ± 0.01*</td>
<td>0.29 ± 0.01*</td>
<td>0.37 ± 0.01*</td>
<td>0.18 ± 0.01</td>
</tr>
<tr>
<td>Starch (g per 100 mL)</td>
<td>1.05 ± 0.07</td>
<td>0.68 ± 0.04*</td>
<td>0.64 ± 0.04*</td>
<td>0.69 ± 0.02*</td>
<td>0.66 ± 0.02*</td>
</tr>
<tr>
<td>pH</td>
<td>6.25 ± 0.01</td>
<td>6.05 ± 0.01</td>
<td>6.29 ± 0.04</td>
<td>6.32 ± 0.03</td>
<td>6.30 ± 0.01</td>
</tr>
<tr>
<td>Total carbohydrates (g per 100 mL)</td>
<td>10.81 ± 0.08</td>
<td>4.51 ± 0.12*</td>
<td>5.02 ± 0.05*</td>
<td>4.9 ± 0.09*</td>
<td>4.91 ± 0.11*</td>
</tr>
<tr>
<td>Energy (kJ per 100 mL)</td>
<td>253.04 ± 0.84</td>
<td>113.14 ± 1.04*</td>
<td>120.79 ± 0.57*</td>
<td>118.20 ± 0.79*</td>
<td>115.31 ± 0.92*</td>
</tr>
</tbody>
</table>

* denotes a statistically significant difference (p<0.05)

### Table 3 Sugars compositions and glycaemic index of quinoa-based beverages

<table>
<thead>
<tr>
<th>Sugar Type</th>
<th>Commercial drink</th>
<th>Beverage A</th>
<th>Beverage B</th>
<th>Beverage C</th>
<th>Beverage D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>2.43 ± 0.05</td>
<td>1.33 ± 0.03</td>
<td>1.87 ± 0.00*</td>
<td>1.36 ± 0.02*</td>
<td>1.83 ± 0.01*</td>
</tr>
<tr>
<td>Maltose</td>
<td>2.45 ± 0.03</td>
<td>1.45 ± 0.02*</td>
<td>1.42 ± 0.02*</td>
<td>1.42 ± 0.01*</td>
<td>1.35 ± 0.00*</td>
</tr>
<tr>
<td>Fructose</td>
<td>0.04 ± 0.01</td>
<td>0.05 ± 0.00</td>
<td>2.38 ± 0.01*</td>
<td>0.07 ± 0.00*</td>
<td>2.55 ± 0.03*</td>
</tr>
<tr>
<td>predicted GI</td>
<td>75.68 ± 0.49</td>
<td>68.70 ± 0.65*</td>
<td>63.72 ± 0.57*</td>
<td>68.97 ± 0.82*</td>
<td>62.78 ± 0.71*</td>
</tr>
</tbody>
</table>

* denotes a statistically significant difference (p<0.05)

### Colour of beverages

Colour is one of the most important quality attributes for plant-based beverages (Clydesdale, 1991; Jeske et al., 2017). Colour of samples was characterised as WI (Table 4). This parameter indicates the degree of whiteness and mathematically combines lightness and yellow–blue into a single term (Milovanovic et al., 2020; Al-Hilalpy et al., 2022). WI of developed beverages A and C were similar to commercial drink and quinoa drink that was previously reported by Jeske et al. (2017). The results also concluded that samples sweetened with inulin and agave syrup had significantly different WI, whereas beverages contained inulin were characterised by about 11.3-12.4% higher WI values. It could be probably due to the fact, that inulin is white in colour and has high WI and the colour of agave syrup can range from light amber to dark amber depending on the processing steps applied during its manufacture (Willem and Low, 2012; Ahmed and Rashid, 2019) (WI of applied sweeteners are shown in the Table 4).

### Table 4 Whiteness index of raw materials, quinoa- based beverages and commercial drinks

<table>
<thead>
<tr>
<th>Quinoa</th>
<th>Inulin</th>
<th>Xanthan gum</th>
<th>Agave syrup</th>
</tr>
</thead>
<tbody>
<tr>
<td>81.17 ± 0.57*</td>
<td>95.58 ± 0.52*</td>
<td>91.19 ± 0.15*</td>
<td>37.04 ± 0.29*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Beverages</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>WI</td>
<td>72.96 ± 0.04</td>
<td>63.91 ± 0.01*</td>
<td>72.28 ± 0.25</td>
<td>64.72 ± 0.66*</td>
</tr>
</tbody>
</table>

### Technological properties of beverages

Technological properties of quinoa beverages are shown in the Table 5. Viscosity is an essential quality parameter for obtaining food products with desirable attributes (Zhao et al., 2003). It was determined that beverages including xanthan gum were characterised by higher viscosity than other beverages. It was already documented that, xanthan gum increases the viscosity of beverages and also supports textural stability by reducing serum separation (Kaur and Tanwar, 2016; Hosseini et al., 2016). Plant-based beverages represent unstable colloidal systems characterised by the presence of immiscible (or partially miscible) colloidal particles that are dispersed in the aqueous phase (Codina-Torrella et al., 2017). Serum separation occurs in beverages due to the aggregation and sedimentation of these particles during storage (Kokosy and Kille, 2004). No serum separation was observed after storage of beverages for 15 days at 5°C.

WHC of developed beverages ranged from 74.32 to 87.83%. Previously, Demitrelo et al. (2021) declared higher WHC in emmer beverages fortified with fruit juices (95.50-99.00%). On the opposite, lower WHC was observed by Lorusso et al. (2018) for quinoa like yoghurt beverages (63.00-70.00%). It was also found that beverages containing xanthan gum (beverages A and B) showed significantly higher WHC than beverages C and D and commercial drink. Bahrami et al. (2013) and Aidar et al. (2021) described that the addition of gums and gum mixtures resulted in higher WHC of the final products. Moreover, it is well known that WHC depends on the type of water binding and trapping in particular cells or between other ingredients (Kurek et al., 2018).
Sensory evaluation of beverages

The sensory evaluation results of beverages are summarised in Table 6. From the sensory assessment, concluded that no significant differences were found in the consistency of evaluated commercial beverage and beverages included xanthan gum (beverages A and B). Moreover, it was found that beverages sweetened by agave syrup had about 14.1-16.3% higher taste score compared to beverages sweetened by inulin. This could be due to the fact, that inulin has a slight sweet taste and has only 10% sweetness in comparison with 100% for sucrose (Mudannayake et al., 2022), on the other hand, agave syrup is 1.8 times sweeter than sucrose (Vahedi and Mousazadeh, 2016).

CONCLUSION

The potential of underutilised crop quinoa as a raw material for production of non-dairy beverages was presented in this study. It was concluded that pretreatment of seeds by desaponification removed saponins, bitter substances, which could decrease the acceptance of quinoa like products and application of thermostable alpha amylase during the processing effectively reduced starch content in the beverages.

Developed beverages contained 0.60-0.63 g per 100 mL protein and had a medium GI. Moreover, it was found that all the developed beverages showed good stability without the serum separation during storage. All beverages that contained xanthan gum had higher viscosity and WHC than other beverages. Sensory evaluation showed that no significant differences were found in consistency of beverages containing xanthan gum and the control sample (commercial quinoa drink available in the Slovak markets). On the other hand, developed beverages had lower overall acceptance than control sample despite the fact that they were sweetened with low GI natural sweeteners. It was also determined that agave syrup was more acceptable as a sweetener due to its higher sweetness compared to inulin. In conclusion, quinoa is a nutritionally rich raw material with absence of gluten and low GI that could be useful for the production of new or reformulated beverages for a group of consumers with specific nutritional needs. However, more research is needed not only to increase sensory acceptance of these products by consumers, but also to determine their nutritional profile and glycemic properties.

Acknowledgments: This publication was supported by grant VEGA No. 1/0583/20 and by the Operational Program Integrated Infrastructure within the project: Demand-driven research for the sustainable and innovative food, Drive4SIFood 313011V336.

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