Solvent retention capacity as a useful tool for quality evaluation of flours produced from Slovak bred wheat varieties

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Abstract: Wheat varieties (IS Danubius and MS Luneta) bred in Slovakia were assessed for their bakery potential. It was found that flour produced from IS Danubius was characterised by significantly higher level of wet and dry gluten content (30.91 and 20.53 %, respectively) and exhibited higher gluten swelling capacity (29.3 %) in comparison to commercial wheat flour that is usually available in Slovak markets. Solvent retention capacity (solvation in specific solvents) of the tested flours was also determined. The measurements showed that these parameters significantly differ from those determined for commercially available flour, whereas the flour produced from IS Danubius wheat variety had the highest lactic acid retention capacity (124.15 %). Correlation analysis indicated strong positive correlations between solvent retention capacity values and gluten characteristics. Furthermore, it was found that baked rolls prepared from IS Danubius flour showed significantly higher loaf volume compared to commercial wheat flour. This study proves lactic acid retention capacity and sucrose retention capacity as parameters enabling the prediction of gluten network quality in dough and of qualitative parameters of baked goods. From the sensory evaluation resulted that the highest score for overall acceptance was observed in IS Danubius baked rolls, which significantly differs from both MS Luneta and commercial wheat flour.

Keywords: baked rolls, gluten, sensory evaluation, solvent retention capacity, wheat varieties

Introduction

Wheat is the most widely grown crop in different environments and climate conditions because of its great nutritional and economic potential. It is cultivated in two forms, spring, and winter (Dizlek and Awika, 2023). Worldwide, wheat is harvested on more than 220 million hectares while spring forms of wheat still predominate globally (Tadesse et al., 2019). This cereal grain currently provides approximately 20 percent of the total caloric intake of humans. It contains essential amino acids, minerals, and vitamins, coupled with nutritionally beneficial secondary metabolites and dietary fibres (Hellemans et al., 2018).

Enhancing crop yield is important to keep pace with population growth and increasing demand. However, persistent climate trends pose a threat to wheat yields, potentially limiting growth in various regions. Spring wheat is currently cultivated in tropical and subtropical environments often nearing or surpassing optimal temperatures especially during the later stages of grain filling. In addition to conventional agronomic adjustments, a frequently suggested adaptation approach involves the development of new wheat varieties. These varieties aim to integrate enhanced heat tolerance with other coveted traits, including disease resistance and the potential for high yields (Hellemans et al., 2018; Kiszonas and Morris, 2018; Dizlek and Awika, 2023). In the past decades, breeding has improved wheat quality, including flour quality, dough rheological properties, and final product quality (Kiszonas and Morris, 2018).

As wheat flour constitutes the main component of baked products, evaluating its quality contributes to final product quality (Kweon et al., 2011; López and Simsek, 2021). The baking performance of wheat flour is determined by its components, mainly by the quality and concentration of proteins. The most important contribution to baking performance is attributed to the major endosperm protein, gluten, which represents an essential food component because of its rheological and functional properties (Laidig et al., 2017). Analysing the specific functional contributions of each component in flour leads to a more accurate prediction of overall flour functionality. This understanding of the mechanisms behind dough mixing and baking allows reaching optimized product quality. In this regard, solvent retention capacity (SRC) method is a valuable tool to assess flour functionality for soft wheat applications (López and Simsek, 2021; Gong et al., 2023). The SRC test functions as a
solvation assay for flours, relying on the enhanced swelling behaviour of individual polymer networks in specific diagnostic solvents — water, lactic acid, sodium carbonate, and sucrose. These solvents are strategically chosen to predict the functional contribution of each flour component. Widely adopted by wheat breeders, millers, bakers, and cereal research scientists, the SRC method has found application in evaluating relationships between flour SRC profiles and final product quality (Švec a Hrušková, 2017; Gong et al., 2023).

The aim of this study was to evaluate the potential of two Slovak registered wheat varieties (IS Danubius and MS Luneta) for bakery purposes. Gluten characteristics, proximate composition, hydrating properties, and SRC of flours were also determined.

**Material and Methods**

**Raw materials**

Wheat flours produced from IS Danubius and MS Luneta varieties were assessed in this study. These samples were obtained from the Research Institute of Plant Production, Piešťany, Slovakia. IS Danubius represents a wheat variety bred by crossbreeding the varieties IS Escoria and Bohemia. Commercially produced fine wheat flour (Mlyn Kolárovo a.s., Slovak Republic, particle size 160–250 μm) (used as a control sample) and other ingredients (vegetable oil, sugar, salt, yeasts) used for the preparation of wheat rolls were purchased in a Slovak local market.

**Evaluation of flour samples**

The following gluten characteristics were determined in wheat flour samples: wet gluten content, gluten ductility (cm), swelling capacity (cm³) (STN ISO 46 1011-9), dry gluten content (Kohajdová et al., 2013). Gravimetric method was used to determine moisture in the samples (ICC Standard No. 110/1). Flour acidity was measured according to Kohajdová et al. (2013). Retention capacity of wheat flours and gluten performance index were estimated according to a method adapted from Dvořáček et al. (2012). Starch content was determined by the polarimetric method of Ewers (Alkurdi and Supuka, 2015). Hydrating properties, water holding capacity (WHC), and water retention capacity (WRC) of flour samples were measured according to the method described by Raghavendra et al. (2004).

**Rolls preparation**

Wheat rolls were prepared according to Kohajdová et al. (2013). The original recipe includes 300 g of wheat flour, 12.06 g of yeasts, 7.5 g of vegetable oil, 5.63 g of salt, 3.22 g of sugar and water to achieve

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**Fig. 1.** Flow chart of wheat roll preparation (Kohajdová et al., 2013).

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farinographic consistency of 400 BU (Brabender units). The procedure is presented in Fig. 1 (Kohajdová et al., 2013).

**Evaluation of baked rolls**

Qualitative parameters of baked rolls were determined two hours after baking. Baking losses (%) represent the weight loss of the product after baking. This parameter was computed as a difference between product weight before and after baking (Kohajdová et al., 2013). Loaf volume (cm³) of baked rolls was estimated by the rapeseed displacement method (Lauková et al., 2016). Loaf specific volume (cm³/100 g) was calculated according to Kohajdová et al. (2013). Cambering was calculated as a ratio of rolls height and width (Lauková et al., 2016).

**Sensory evaluation**

Products were evaluated by seven trained judges using a five-point hedonic scale according to the method described by Kohajdová et al. (2013). The panel consisted of staff and students of the Faculty of Chemical and Food Technology, Slovak University of Technology, Bratislava, Slovakia. The assessed parameters were: shape of products, colour and hardness of crust and crumb, flavour and taste of baked rolls, adhesiveness to palate, springiness, and porosity. Overall acceptability of baked rolls was determined using a 100 mm graphic non-struc-
tured line segment with the description of extremes (100 % — fully acceptable and 0 % — nonacceptable) (Lauková et al., 2016).

**Statistical analysis**

All analyses were performed in triplicate. The results were expressed as the mean value ± standard deviation. Analysis of variance was conducted to establish differences (p < 0.05). Fisher’s least significant differences (LSD) test was used to describe the significance of the differences between the Slovak commercial flour sample (control) and flours produced from IS Danubius and MS Luneta wheat varieties. Pearson’s correlation test was applied to determine the relationship between SRC values, gluten characteristics, hydrating properties, and starch content using the statistical software Statgraphic version 19 (Statsoft-Inc., Virginia, USA).

**Results and Discussion**

**Flour evaluation**

Wheat flour quality is mainly affected by the amount and characteristics of flour proteins (Dizlek and Awika, 2023). Wheat contains a complex mixture of proteins characterized by their distinct ability to create a viscoelastic dough when mixed with water. Gluten characteristics of tested flours are listed in Tab. 1, with gluten, protein constituent of flour responsible for imparting elasticity and strength to the dough, described as the resilient mass remaining after washing wheat dough to eliminate starch granules and water-soluble components (Balamurugan et al., 2018; STN 46 1011-9). Wet gluten yield of tested wheat flours represented 28.24, 28.51 and 30.91 % in dry matter, for control flour, and that produced from MS Luneta and IS Danubius wheat variety, respectively. According to Popovska (2023), optimal wet gluten content for high-quality bread flour is within the range of 30—36 % in dry matter. Dry gluten is the final product after gluten extraction and drying (Kaushik et al., 2015). The percentage of dry gluten in wheat samples was 18.20, 19.32, and 20.53 % in dry matter. According to Kohajdová et al. (2013), dry gluten content represents approximately 1/3 of the wet gluten amount. Thus, flour produced from IS Danubius wheat variety has the best quality from the tested samples. Rheological and functional properties of gluten depend on the ratio of gliadins and glutenins. Each constituent has a distinct function important for the determination of viscoelastic properties and final product quality. Wheat prolams (gliadins) contribute to gluten ductility, the ability to maintain cohesion under tension (Biesiekierski, 2017). Based on the results, gluten ductility of the studied samples fell within the range considered medium ductile gluten, which is the most suitable for baked goods production (Kohajdová et al., 2013). Gluten swelling capacity is the ability to increase volume in weak acid conditions while maintaining its consistency; this parameter defines flour quality and suitability for bakery purposes (Kohajdová et al., 2013). According to Zálešáková et al. (2004), swelling capacity of gluten washed from high-quality wheat flour is higher than 13 cm³. All tested samples met this criterion, with IS Danubius and MS Luneta exhibiting significantly higher values compared to the control sample.

Statistical analysis showed that flour produced from the IS Danubius wheat variety had significantly higher wet and dry gluten content than other samples. Statistically significant differences were also found in gluten characteristics of flours produced from the studied wheat (results are not shown). Chemical composition and hydrating properties of wheat flours are summarised in Tab. 2. Moisture content of powdered materials is a critical parameter influencing their cohesiveness and affecting product stability during storage (Fitzpatrick, 2013). It was determined that flours varied significantly in moisture content, but these values were in agreement with legislative requirements defined in the Food Code of the Slovak Republic (15 %). Flour acidity serves as an indicator of its freshness and the way in which it is stored. During storage, titratable acidity of flour gradually increases, while the rate of acidity increase in flour is directly proportional to the storage temperature and ash content (Rosentrater and Evers, 2018). The acidity of control sample was significantly higher compared with other samples, although they were

<p>| Tab. 1. Gluten characteristics of tested flours. |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|</p>
<table>
<thead>
<tr>
<th></th>
<th>Wet gluten content ( % in dry matter)</th>
<th>Dry gluten content ( % in dry matter)</th>
<th>Gluten ductility (cm)</th>
<th>Gluten swelling capacity (cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>28.24 ±0.31</td>
<td>18.20 ±0.24</td>
<td>11.90 ±0.14</td>
<td>22.67 ±0.47</td>
</tr>
<tr>
<td>IS Danubius</td>
<td>30.91 ±0.37*</td>
<td>20.53 ±0.47*</td>
<td>12.07 ±0.17</td>
<td>29.33 ±0.47*</td>
</tr>
<tr>
<td>MS Luneta</td>
<td>28.51 ±0.02</td>
<td>19.32 ±0.42</td>
<td>11.67 ±0.12</td>
<td>25.00 ±0.00*</td>
</tr>
</tbody>
</table>

*denotes a statistically significant difference at p < 0.05 level.
all in acceptable ranges recommended for wheat (20—40 mmol/kg) (Kohajdová et al., 2013).

Starch is the major component of wheat flour and its content and characteristics directly influence rheological properties of dough and quality of final products (Kohajdová et al., 2013). No significant differences in this parameter were found in the control sample and other flours. On the other hand, flours produced from IS Danubius and MS Luneta significantly differ in starch content. However, all flour samples confirm the claim that starch makes up about 80.0 % of wheat flour (Eriksson et al., 2014).

Functional properties (including hydrating properties WHC and WRC) of wheat flour determine its application and use for various food products based on the desirable texture (Lauková et al., 2016). WHC is connected to the porous matrix structure created by polysaccharide chains, which have the capability to retain substantial amounts of water through hydrogen bonding (Zhu et al., 2015). WRC in wheat flour refers to the ability of the flour to hold and retain water after the application of an external force (Liu et al., 2018). No significant differences in WHC were found in the evaluated samples. However, WRC values of flours produced from IS Danubius and MS Luneta significantly differed from those of control flour. WHC values confirm the claim that starch makes up about 80.0 % of wheat flour (Eriksson et al., 2014).

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Solvent retention capacity

SRC is a solvation test predicting flour functionality and swelling ability of flour polymeric constituents. For the SRC method, four standard solvents are used to evaluate which specific flour component is responsible for a given variation in flour-swelling behaviour (Kweon et al., 2011; Wessels et al., 2020). Diagnostic solvents included: 5 % lactic acid associated with glutenin characteristics and gluten strength, 5 % sodium carbonate with damaged starch content, 50 % sucrose with pentosans (arabinoxylans) content, and distilled water which is influenced by all flour components (Li et al., 2014). SRC values of studied flours are presented in Tab. 3. Concerning the standard solvents, the trend of SRC profile of all samples is water retention capacity (WSRC) < sodium carbonate retention capacity (SCSRC) < sucrose retention capacity (SUSRC) < lactic acid retention capacity (LASRC), which is in accordance with the trend obtained by López and Simsek (2021), where the supplemental solvents and gluten quality were studied. According to the obtained results, SCSRC of studied samples showed the highest variation in values (73.62—89.85 %), while the lower variation was found for WSRC (68.05—77.75 %).

LASRC value of control flour significantly differs from other flours. Previously, Li et al. (2014) described that this fact is related to protein content and gluten functionality. However, Lindgren and Simsek (2016) and López and Simsek (2021) reported that LASRC is specifically connected with glutenin content instead of total protein content since glutenins are soluble in acid solutions. In general, higher LASRC values indicate bakery products with higher loaf volume, dough strength, and better gluten quality (Kweon et al., 2011). Alkaline pH of the sodium carbonate solution is essential for interactions with damaged starch. Damaged starch represents small starch particles torn away from bigger starch granules during wheat milling which have high water holding capacity (Li et al., 2014; Lindgren and Simsek, 2016). Control flour sample showed the highest SCSRC, and its value differs significantly from the tested flours. Higher SCSRC values were already reported to indicate higher starch damage. Damaged smaller starch granules have better hydration and swelling capacity during dough preparation. A certain degree of starch damage is desirable to achieve high baking quality (Dvořáček et al., 2012).

Considering the polysaccharide component of grain, non-starch polysaccharide content, namely soluble and insoluble pentosans (arabinoxylans), is mentioned as a significant quality component. These substances play a role in the structural function of gluten complex and, at the same time, in water holding capacity (Dvořáček et al., 2012). Neutral pH of the sucrose solvent facilitates the swelling...
of arabinoxylans and interacts specifically with the xylan backbone (Kweon et al., 2011; Lindgren and Simsek, 2016). According to Dvořáček et al. (2012), the interval range of SUSRC for high baking quality of flour is 104.4–113.0 %. It was found that only sample IS Danubius meets the set criteria for high baking quality. Wessels et al. (2020) came to the same conclusion when evaluating the SUSRC of wheat flour in different varieties cultivated in South Africa.

Water represents a reference SRC solvent as it is associated with all functional flour components (Kweon et al., 2011). Among the three samples, IS Danubius flour (72.74 %) showed higher WSRC values. Also, it was determined that WSRC of the control sample was significantly different compared to the other flours studied. The WSRC value is specifically connected with water holding capacity of flour, a crucial factor for the processing and final quality of baked goods. However, the other three SRC solvents exhibit better compatibility with the individual polymer components of flour (Lindgren and Simsek, 2016).

Gluten performance index (GPI) is a derived value based on the lactic acid, sodium carbonate, and sucrose SRC values. It is a predictive parameter which better indicates overall gluten performance in the presence of other modulation networks as the LASRC value alone (Li et al., 2014). GPI can be used as a credible parameter for bread-baking performance prediction (Jeon et al., 2019). GPI of the control sample was significantly lower than that calculated for other tested flours. Jeon et al. (2019) documented that baked goods produced from flours with higher GPI values (0.60–0.70) are likely to exhibit a firmer and more viscoelastic texture after baking. Consistent with these results, IS Danubius and MS Luneta showed significantly higher GPI values than the control sample, suggesting better functionality and quality during the baking process.

Correlation analysis
In cereal research, correlation analysis is used to measure the strength of the linear relationship between two variables and to compute their association. This statistical method is useful in revealing the magnitude and direction of the relationship between different parameters contributing to the quality of cereal products (Chong et al., 2014). Correlation analysis was applied to estimate the relationships between the SRC values, gluten characteristics, functional properties, and starch content (Tab. 4). High correlations were observed among different SRCs and GPI. SC SRC showed strong positive correlation with WSRC (r = 0.968) and SUSRC (r = 0.967) at the 0.05 % level of significance. High correlation between SC SRC, WSCR, and starch content indicate that starch damage is the main indicator for the determination of water absorption in flours (Ram et al., 2005). Similar results were also reported by Siddiqi et al. (2022) in their study of different wheat cultivars. GPI showed high negative correlations with WSRC (r = –0.925), SUSRC (r = –0.925), SC SRC (r = –0.798), and significant correlation with dry gluten content (r = 0.789, p < 0.05). Positive correlation between GPI and dry gluten can be explained by the fact that GPI is a predictor of gluten quality (Siddiqi et al., 2022). LASRC values positively correlate with wet gluten content (r = 0.945, p < 0.05), dry gluten content (r = 0.737, p < 0.05), and gluten swelling capacity (r = 0.994, p < 0.05) since lactic acid SRC reflects gluten characteristics and functionality (Lindgren and Simsek, 216). Likewise, according to the findings of Wessels et al. (2020) and Gong et al. (2023), positive correlations in LASRC and gluten characteristics were found. Strong negative correlation between LASRC and starch content was also found (r = –0.935) as higher levels of damaged starch led to an increase in lactic acid retention (Dvořáček et al., 2012). Also, WRC was found to be in positive relation with WSRC (r = 0.992, p < 0.05), SUSRC (r = 0.992, p < 0.05), SC SRC (r = 0.928, p < 0.05), and WHC (r = 0.890, p < 0.05). WHC showed positive correlation with SUSRC (r = 0.792, p < 0.05) and WRSC (r = 0.719), and non-significant negative correlations with wet gluten (r = –0.770), dry gluten (r = –0.960), and GPI (r = –0.929). This can be explained due to the ability of water to

Tab. 3. Retention capacity of wheat flours.

<table>
<thead>
<tr>
<th>(%)</th>
<th>WSRC</th>
<th>SUSRC</th>
<th>LASRC</th>
<th>SC SRC</th>
<th>GPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>71.75 ±0.76</td>
<td>106.12 ±0.43</td>
<td>117.06 ±0.13</td>
<td>89.85 ±0.59</td>
<td>0.60 ±0.00</td>
</tr>
<tr>
<td>IS Danubius</td>
<td>72.74 ±0.26*</td>
<td>100.04 ±1.75*</td>
<td>124.15 ±0.74*</td>
<td>85.14 ±0.58*</td>
<td>0.67 ±0.01*</td>
</tr>
<tr>
<td>MS Luneta</td>
<td>68.03 ±0.11*</td>
<td>94.36 ±0.57*</td>
<td>114.71 ±0.37*</td>
<td>73.62 ±0.32*</td>
<td>0.68 ±0.00*</td>
</tr>
</tbody>
</table>

Note: WSRC — water retention capacity, SUSRC — sucrose retention capacity, LASRC — lactic acid retention capacity, SC SRC — sodium carbonate retention capacity, GPI — gluten performance index

*denotes a statistically significant difference at p < 0.05 level.

26 Holkovičová T et al., Solvent retention capacity as a useful tool for quality evaluation of flours...
swell up and hydrate all polymeric components of flour (Nogueira et al., 2021). Wet gluten was significantly positively correlated with dry gluten content ($r = 0.917$, $p < 0.05$) and swelling capacity ($r = 0.903$, $p < 0.05$).

Qualitative parameters of baked rolls

Qualitative parameters of baked goods refer to the characteristics and attributes that define the sensory and physical qualities of final products (Nashat and Abdullah, 2016). Qualitative parameters of baked rolls are presented in Tab. 5 and their photo documentation is showed in Fig. 2. Loaf volume and specific volume represent important criteria in the assessment of the quality of fresh bread in both industrial quality control and consumer evaluation (Rossmann et al., 2020). While it serves as an indicator of gluten content in bread, it is essential to note that other components, including starch and fibre, also play significant role in determining the volume and specific volume of bread. Therefore, specific volume is a comprehensive measure reflecting various constituents that collectively contribute to the overall quality of bread (Laidig et al., 2022). Significantly higher loaf volume and specific volume was observed in baked rolls produced from the IS Danubius wheat variety compared to other samples; this can be ascribed to higher gluten content in this flour sample (Jankielsohn and Miles, 2017). These findings are in agreement with the study of Schopf and Scherf (2021) who concluded that variations in loaf volume are most affected by the amount of total gluten proteins.

Cambering, expressed as the ratio of loaf height to width, indicates the proportion of these dimensions in loaves. A higher cambering value is preferred and indicates a product with more appealing shape. Ideally, the loaf should exhibit an arched form, smoothly transitioning from the bottom to the upper crust, with higher width-to-height ratio (Bojánská and Mocko, 2014). Cambering values falling within the range of 0.60 to 0.70 are regarded

<table>
<thead>
<tr>
<th>Parameters</th>
<th>WGC (%)</th>
<th>DGC (%)</th>
<th>GSC (cm$^3$)</th>
<th>WSRC (%)</th>
<th>SUSRC (%)</th>
<th>LASRC (%)</th>
<th>SCSRC (%)</th>
<th>GPI (%)</th>
<th>SC (%)</th>
<th>WHC (g · g$^{-1}$)</th>
<th>WRC (g · g$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WGC (%)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DGC (%)</td>
<td>0.917*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GSC (cm$^3$)</td>
<td>0.903*</td>
<td>0.658*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSRC (%)</td>
<td>-0.110</td>
<td>-0.496</td>
<td>0.328</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUSRC (%)</td>
<td>-0.111</td>
<td>-0.498</td>
<td>0.326</td>
<td>0.999*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LASRC (%)</td>
<td>0.945*</td>
<td>0.737*</td>
<td>0.994*</td>
<td>0.222</td>
<td>0.220</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCSRC (%)</td>
<td>0.145</td>
<td>-0.261</td>
<td>0.556*</td>
<td>0.968*</td>
<td>0.967*</td>
<td>0.461</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPI (%)</td>
<td>0.480</td>
<td>0.789*</td>
<td>0.057*</td>
<td>-0.925</td>
<td>-0.925</td>
<td>0.166</td>
<td>-0.798</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SC (%)</td>
<td>-0.767</td>
<td>-0.449</td>
<td>-0.968</td>
<td>-0.553</td>
<td>-0.552</td>
<td>-0.935</td>
<td>-0.746</td>
<td>0.194</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WHC (g · g$^{-1}$)</td>
<td>-0.770</td>
<td>-0.960</td>
<td>-0.421</td>
<td>0.719</td>
<td>0.720*</td>
<td>-0.519</td>
<td>0.520*</td>
<td>-0.929</td>
<td>0.182</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WRC (g · g$^{-1}$)</td>
<td>-0.233</td>
<td>-0.601</td>
<td>0.207</td>
<td>0.992*</td>
<td>0.992*</td>
<td>0.098</td>
<td>0.928*</td>
<td>-0.965</td>
<td>-0.444</td>
<td>0.800*</td>
<td>1</td>
</tr>
</tbody>
</table>

*indicates a statistically significant difference at $p < 0.05$ level.

Note: WGC — wet gluten content, DGC — dry gluten content, GSC — Gluten swelling capacity, WSRC — water retention capacity, SUSRC — sucrose retention capacity, LASRC — lactic acid retention capacity, SCSRC — sodium carbonate retention capacity, GPI — gluten performance index, SC — starch content, WHC — water holding capacity, WRC — water retention capacity

Fig. 2. Baked rolls.
as favourable, while values below 0.50 are considered inadequate (Kohajdová et al., 2013). From the results it can be concluded that all evaluated samples met the criteria and had good cambering (above 0.60). Best cambering value was observed in the IS Danubius flour sample (0.64), which showed about 3.13 % higher values than the control sample (0.62).

Baking losses are defined as the reduction in the weight of baked goods after the baking process. These losses primarily occur due to the evaporation of moisture during baking. Factors influencing baking losses include the weight of the bakery product, its shape, and moisture content. Typical baking losses for baked goods generally fall within the range from 10 to 15 % (Bojňanská and Mocko, 2014). Baking losses were appropriate in all assessed samples, however, IS Danubius sample showed significantly lower value (8.49 %) than MS Luneta and control samples.

### Sensory evaluation

Results of sensory evaluation of individual samples are presented in Fig. 3. Colour of crust and crumb of the baked rolls had the following decreasing trend: IS Danubius > Control > MS Luneta. The colour of crust can be influenced mainly by the flour type, baking temperature and time, presence of enzymes such as amylases and proteases, initial and final humidity (Castro et al., 2017). Baked rolls made from the IS Danubius flour sample showed significantly higher (p < 0.05) values of hardness of crust and crumb than baked rolls made from MS Luneta, which can be influenced by higher gluten content in the raw material. The protein content in flour, primarily gluten, plays a vital role in the texture of the baked product. Higher protein content often results in a firmer structure. Moreover, the way the dough is handled, including kneading and shaping, influences gluten development, overall structure, and hardness (Puerta et al., 2021). Baked goods made from IS Danubius wheat variety and control flour had a more acceptable flavour compared to those made from MS Luneta flour. Adhesiveness describes the tendency of the food to stick or adhere to surfaces, such as teeth or the mouth, and reflects the texture and mouthfeel experienced during eating (Durán-Aranguren et al., 2023). Adhesiveness of IS Danubius and MS Luneta baked rolls exhibited significantly higher scores compared to the control flour sample. Dough with good adhesiveness displays a well-developed gluten network (Yovchev et al., 2015). Springiness denotes the speed at which a sample returns to its original shape after deformation (Guiné et al., 2022). The highest value of this textural parameter was found in IS Danubius baked rolls. High springiness values of the baked goods are connected with the freshness as favourable, while values below 0.50 are considered inadequate (Kohajdová et al., 2013). From the results it can be concluded that all evaluated samples met the criteria and had good cambering (above 0.60). Best cambering value was observed in the IS Danubius flour sample (0.64), which showed about 3.13 % higher values than the control sample (0.62).

### Tab. 5. Qualitative parameters of baked rolls.

<table>
<thead>
<tr>
<th></th>
<th>Baking loss (%)</th>
<th>Loaf volume (cm³)</th>
<th>Loaf specific volume (cm³/100g)</th>
<th>Cambering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>10.80 ±0.44</td>
<td>261.25 ±4.15</td>
<td>287.18 ±3.66</td>
<td>0.62 ±0.02</td>
</tr>
<tr>
<td>IS Danubius</td>
<td>8.49 ±0.30*</td>
<td>266.25 ±4.15*</td>
<td>292.14 ±2.98</td>
<td>0.64 ±0.04</td>
</tr>
<tr>
<td>MS Luneta</td>
<td>11.54 ±0.61</td>
<td>240.00 ±3.54*</td>
<td>267.12 ±3.25*</td>
<td>0.61 ±0.03</td>
</tr>
</tbody>
</table>

*denotes a statistically significant difference at p < 0.05 level.
and elasticity, and thus are preferred (Král et al., 2018). Statistical analysis showed that MS Luneta baked rolls had significantly lower springiness than the control sample. Statistically significant differences in this parameter were also found between IS Danubius and MS Luneta baked rolls. The results show that the porosity of IS Danubius baked rolls significantly differs from that of MS Luneta baked rolls. According to Rathnayake et al. (2018), flour with better protein quality and quantity results in baked goods with improved porous structure characterized by uniformly sized gas cells. IS Danubius and control samples obtained the highest score for the shape of baked rolls. The higher content of gluten and the development of dough structure help in maintaining the shape of the baked product while suitable gluten development contributes to their elasticity and structure (Dufour et al., 2024). Regarding the overall acceptance (Fig. 4), all samples were evaluated as pleasant. The scores for overall acceptance showed significant differences (p < 0.01) between control sample and MS Luneta baked rolls. Moreover, significant differences (p < 0.001) were also found between IS Danubius and MS Luneta baked rolls. Baked rolls produced from the IS Danubius wheat variety were rated as the most acceptable by assessors (94 %).

**Conclusion**

Bakery potential of two wheat varieties (IS Danubius and MS Luneta) cultivated in Slovakia was evaluated in this study. Results have distinctly indicated that there is notable (p < 0.05) variability in the physico-chemical, functional, and sensory characteristics of the introduced wheat cultivars. Statistical analysis showed that significant differences in gluten content, gluten swelling capacity, and in retention capacity parameters (WSRC, SUSRC, LASRC, SCSR) were found not only between the control sample and flour prepared from the studied wheat varieties but also between IS Danubius and MS Luneta flours. Baked rolls prepared from IS Danubius wheat variety showed about 20 % higher sensory acceptability than those from MS Luneta flour. In conclusion, the winter wheat variety IS Danubius showed good suitability for baked goods production and has thus been recommended for cultivation and subsequent use in the baking industry. Further studies will be performed to characterise rheological and textural properties of baked rolls to provide data on the elastic and viscous behaviour of dough and the characteristics of baked rolls.

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**References**