Journal of Applied Biology & Biotechnology Vol. X(XX), pp. 1-8, 2024
Available online at http://www.jabonline.in
DOI: 10.7324/JABB.2024.189470

Comprehensive evaluation of agronomic and qualitative characteristics in selected wheat cultivars in Kosovo

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ARTICLE INFO

Article history:
Received on: February 04, 2024
Accepted on: June 01, 2024
Available online: ***

Key words:
Wheat, Cultivars,
Agronomic parameters,
Quality parameters,
Baking test.

ABSTRACT

Cereals, such as wheat, hold significant nutritional and economic value globally, particularly in regions like Kosovo, where wheat cultivation plays a vital role in the production of staple foods. This study examines three predominant wheat cultivars in Kosovo, namely "Pobeda," "Euclide," and "Europe," focusing on agronomic traits and end product quality to ascertain their suitability for cultivation and subsequent product applications. Through a comprehensive evaluation encompassing agronomic, qualitative, and baking parameters, the study aims to provide insights into cultivar-specific characteristics that influence both cultivation practices and end product quality. Key findings reveal notable disparities among cultivars in agronomic parameters, with "Euclide" demonstrating superior flour extraction rates (42.97%) and exemplary performance in baking evaluations. Noteworthy variations in chemical composition, particularly in fat and fiber content, were observed, with "Pobeda" exhibiting the highest values (2.54% fat content and 3.21% fiber). Despite nonsignificant differences in certain agronomic parameters according to ANOVA results, individual cultivar performance underscored unique traits, highlighting the cultivar-specific influence on overall quality. This research fills a crucial gap by providing a nuanced understanding of wheat cultivars in Kosovo, offering valuable insights for farmers and the baking industry to optimize cultivation techniques and enhance end product quality. The findings advocate for the adoption of cultivar-specific approaches in wheat cultivation and processing, ultimately contributing to sustainable agricultural practices and improved product standards. Overall, this study contributes to the advancement of knowledge in wheat agronomy and quality assessment, facilitating informed decision-making for stakeholders involved in wheat production and processing in Kosovo and beyond.

1. INTRODUCTION

Cereals are crops that are grown all over the world. Wheat, corn, barley, and rye are some of the most cultivated grains due to their nutritional value and economic aspect, and this also depends on the climatic conditions of cultivation in different regions. About 50% of daily calories worldwide are obtained from the consumption of processed cereals in different forms [1].

Domesticated about 10,000 years ago in the Fertile Crescent area of the Near East, wheat has been named one of the oldest crops in the world [2]. It constitutes one of the most important energy sources due to the many roles it performs that are necessary for health. The consumption of wheat in different forms reduces cholesterol levels, reducing the risk of cardiovascular disease. Its antioxidant properties come from the content of flavonoids, phenolic acids, phytosterols, and carotenoids. These properties affect the reduction of free radicals in the body [3]. Regular consumption of wheat or other whole grains is also associated with a reduced risk of cancer. In a study of 23,014 women, a significant correlation was found between whole grain consumption and the appearance of endometrial cancer [4]. This is possible through its nutritional composition, which includes carbohydrates, starch, proteins, lipids, dietary fibers, and various phytochemicals [5], respectively. Proteins comprise about 16% of wheat grains. They are classified according to their solubility in albumin (soluble in water), globulin (in salt solutions), gliadin, and glutenin (in alcohol) [6]. Gluten comprises about 80% of the proteins in wheat flour. This protein gives the dough its viscoelastic properties. In addition to proteins, carbohydrates are a very important component, which comprise about 58% of the grain. This includes glucose, arabinose, xylose, hemicelluloses A and B, and uronic acid, but the main carbohydrate is starch [7]. Wheat carbohydrates have an effect on health through their solubility, which affects blood sugar levels. In this group, fructans are also estimated to have an important impact on the promotion of the absorption of minerals by the body, especially calcium [8]. The high nutritional value also comes from the content of lipids, which are an important group of ingredients that include triglycerides, diglycerides, monoglycerides, N-acyl lysophosphatidyl

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ethanolamine, phosphatidyl ethanolamine, and lysophosphatidyl ethanolamine [9]. The oil extracted from the wheat germ is very rich in vitamins A, D, and E, making it very acceptable for skin health. It influences the improvement of blood circulation and the repair of injured cells in the skin [10,11]. Vitamins and minerals are a large and diverse group, where vitamins include pantothenic acid (B5), thiamine (B1), pyridoxine (B6), niacin (B3), biotin (B8), riboflavin (B2), cobalamin (B12), vitamins K, E, and A, ascorbic acid, along with minerals such as sodium, magnesium, molybdenum, zinc, aluminum, copper, phosphorus, sulfur, iron, and selenium [12,13]. All these components make wheat an exceptionally rich and well-rounded source of nutrients crucial for the optimal functioning of the human body.

Vitamins and minerals have been proven to prevent heart diseases [14]. Furthermore, the presence of dietary fibers in wheat grains makes it possible to reduce the glycemic response after eating, reducing the probability of diabetes. Their role has also been shown to reduce cholesterol and, consequently, coronary heart disease. This role is strengthened by the action of sterols, stanols, and derivatives [5]. Dietary fiber in the wheat grain includes indigestible components that pass through the colon and resist digestion. In this form, they facilitate the function of the intestines, decreasing the transit time of food in the intestines [15]. Fibers in the intestine influence the reduction of colorectal cancer risk, treatment of irritable bowel syndrome, and decrease the risk of hemorrhoids, hypercholesterolemia, hypertension, and type 2 diabetes [10].

China and the USA continue to be the largest global producers, with more than 60% of global production, together with three other countries [16]. About 25% of wheat exports are made by Ukraine and Russia [17]. The demand for grain is constantly increasing, and by 2050 the need for an increase in production of over 840 million tons is predicted [18]. Such a thing can be achieved with good management of arable land and monitoring of bioaerosols for the spread of diseases or pests, climate change, and genetic improvement, but this takes quite a long time. In Kosovo, cereals make up 66% of the arable land surface, with wheat and corn as the main crops. Although climatic changes have affected all regions, in general, the climatic conditions are suitable for the cultivation of cereals [19]. The consumption of agricultural products has not changed much in recent years. The import of agricultural products is done mainly to satisfy the general needs of the population for consumption, and the amount of import depends on the domestic production for the respective year. Kosovo is not very dependent on imports since, according to 2020 data, its own production consists of about 73% wheat and 75% corn as the main cereals [20]. Consequently, to fully cover the requirements for the two main cereals, wheat and corn, the yields must increase by about 30% [21]. There are a lot of cultivars that are cultivated in Kosovo, such as Pobeda, Srilanka, Europa, Euclide, Nicol, Lenta, Luna, and Renesanca. Studies have shown that Pobeda and Renesansa cultivars can achieve high yields even under stressful conditions [22]. For different parameters, different cultivars have various performances. For instance, Slaveya, Iveta, and Aglika have shown high performance in terms of the number of grains per spike, compared to cultivar Savodo. Furthermore, these cultivars showed high resistance to cold [23]. Despite agronomic parameters, wheat cultivars should be selected carefully when they are used in the bakery industry. According to Tomić et al. [24], the Apache cultivar has the lowest performance for bread-specific volume, compared to Pobeda, Gordana, and Zvezdana cultivars. This is also influenced by the gluten index, which is directly related to the quality of bread as an end product.

There are many factors that affect the quality and yield of wheat, including genetics, the environment in which the plant is grown, and the management of agronomic practices [25]. Determination of agronomic and quality attributes is necessary to determine the suitability of specific cultivars in certain climatic conditions and different geographical spaces. Their determination is necessary to ensure higher production, reduce the demand for additional fertilizers, and increase food security.

Despite the wealth of knowledge on the factors influencing wheat quality and yield, there remains a notable gap in understanding how specific wheat cultivars perform under Kosovo's distinct agroecological conditions. Although existing research has explored agronomic and quality parameters in various contexts, there is limited information on the suitability of specific cultivars for cultivation in Kosovo. This study seeks to address this gap by conducting a comprehensive analysis of the key agronomic and quality attributes of prominent wheat cultivars grown in Kosovo. By filling this knowledge gap, our research aims to provide valuable insights into cultivar selection, informing farmers about cultivars with the highest yield and the most suitable attributes to produce products processed by them, with special emphasis on bread.

2. MATERIALS AND METHODS

Research includes analysis of the agronomic and quality parameters of three wheat cultivars: "Pobeda," "Euclide," and "Europe," cultivated in the Fushë-Kosova region of Kosovo. The study site was located at latitude 42°37'57.513062" N and longitude 21°1'11.550146" E in 2022. These cultivars were selected because they are predominantly cultivated in the study region. The chosen wheat cultivars were not specifically released for cultivation in the Fushë-Kosova region but have been used by local farmers for approximately 10 years (2012–2022). The three cultivars underwent standardized agronomic practices, including tillage treatment by plowing, where wheat seeds were sown in parallel rows spaced 20 cm apart and fertilizer application with NPK at 300 kg/ha in autumn and urea at 300 kg/ha in spring. No irrigation or disease management control measures were implemented during the trial period. This standardized approach guaranteed that all cultivars experienced identical conditions, thereby removing possible variables that could affect the results. Each cultivar was replicated three times in the field to ensure statistical reliability. Using this approach, the study aimed to evaluate the agronomic and quality parameters of these cultivars under consistent conditions, providing valuable information on their performance in the local agricultural context. The corresponding weather conditions for this location, including average temperature, humidity, precipitation, and other relevant factors, are presented in Table 1. While wheat cultivation is common in Kosovo,

Table 1: Summary of weather conditions for 2021–22.

Month	Temperature (°C)	Moisture content (%)	Winds (mph)	Pressure (in)	Precipitation (")
October	9.62	73.05	5.68	27.72	0.33
November	8.28	74.45	5.08	27.61	0.26
December	2.58	78.05	5.34	27.52	0.41
January	0.04	74.98	4.95	27.68	0.09
February	5.14	68.02	4.71	27.68	0.06
March	4.36	66.19	5.47	27.62	0.03
April	8.69	58.87	8.00	28.08	0.00
May	15.63	60.65	6.34	27.55	0.30
June	19.93	63.33	5.97	27.63	0.27
July	23.52	59.24	5.45	27.58	0.30
August	22.98	54.92	5.50	27.60	0.08

there is limited research focusing on the performance of specific cultivars, especially in this region. This study fills a significant gap in the literature by providing detailed insights into the performance of these cultivars under local agro-climatic conditions. Moreover, this research contributes valuable data that can inform future studies not only in Kosovo but also in other regions with similar agro-ecological characteristics.

2.1. Agronomic Parameters

Within the framework of agronomic parameters, a comprehensive evaluation was conducted that included yield, weight of 1000 grains, hectoliter weight, and grain size. The determination of the weight of 1000 grains was thoroughly executed using the Contador instrument, an automated grain counter that facilitated precise weight calculation, thus enhancing the reliability of the results. Furthermore, the weight in hectoliters, a critical indicator of grain density and quality, was measured using the Schopper scale, providing results in kg/ha and offering valuable insights into grain characteristics. Furthermore, the grain size distribution was analyzed using the Sortimat system, which classified grains according to size into distinct groups such as 2.8, 2.5, 2.2, and 2.0 mm. Subsequently, each group of grains was individually weighed, and the results were expressed as percentages, allowing a detailed assessment of grain size variability. Using these specialized instruments and methodologies, the study ensured robust and reliable evaluations of agronomic parameters, thus improving the validity and precision of the findings.

2.2. Qualitative Parameters

Qualitative analysis included examination of the degree of flour extraction and the Hagberg falling number. The degree of flour extraction was assessed by grinding 100 g of wheat, sieving the resulting flour through sifters, and measuring its weight. The Hagberg falling number was measured utilizing a Perten instrument, which recorded the duration for the metal plate to descend to the base of the test tube housing the flour sample and water suspension.

Furthermore, the samples were subjected to nutritional analysis using near infrared spectroscopy (NIRS) in accordance with AACC method 39–25 [26]. This analysis provided data on various nutritional components, including moisture, protein, fat, starch, dietary fiber, and ash content. Using NIRS technology, precise measurements were obtained, allowing a comprehensive assessment of the nutritional profile of wheat samples.

2.3. Microscale Baking Test

The flour milled from wheat cultivars was subjected to a microscale baking test, using the ingredients described in Table 2. All the ingredients were mixed for 5 min, followed by the fermentation process at 30°C for 30 min, shaping in pans, a second fermentation for 60 min, and baking for 7 min at 250°C. This test was designed to evaluate the organoleptic parameters of the resulting bread samples, including color and porosity, using a standardized 5-point scale evaluation. A rating of 1 indicated bread with a very bright color and lack of porosity, while a rating of 5 signified bread with a desirable brown color and evenly distributed pores. Additionally, the weight and volume of bread samples were measured in accordance with the AACC 10-05 method [27]. All measurements were conducted in triplicate to ensure the reliability and accuracy of the results.

Table 2: Ingredients used in the preparation of bread samples.

Ingredients	Amount
Flour	40 g
Butter	0.8 g
Salt	0.8 g
Yeast	0.8 g
Water	25 mL

2.4. Statistical Approach

Data obtained from the research were analyzed using IBM SPSS version 27.0 statistical software. Arithmetic means for all parameters were calculated to provide a clear representation of the central tendency of the data. To assess potential differences between different groups, an analysis of variance (one way ANOVA) was employed. Subsequently, Tukey's test was applied to identify significant differences between group means, with a confidence interval of 95% ($p < 0.05$).

3. RESULTS AND DISCUSSION

3.1. Agronomic Parameters

ANOVA showed that there are no significant differences between the three investigated cultivars for yield parameters, weight of 1000 grains, and hectoliter weight ($p > 0.05$). This may have happened because the areas where the samples were taken were close to each other and under the same climatic and geographical conditions. However, the cultivar "Europe" recorded the highest yield, while the cultivar "Euclide" recorded the lowest. Overall, the average yield was high at 626.8 g/m^2. These variations can be attributed to genetic differences in yield potential and agronomic traits between cultivars, as well as the influence of favorable climatic conditions on overall yield performance. Furthermore, these results suggest that the higher yield observed in "Europe" may be attributed to its genetic traits favoring robust growth and disease resistance, whereas the lower yield in "Euclide" could be influenced by genetic factors affecting its lodging resistance and grain size. Even the weight of 1000 grains is an important parameter, on the basis of which the seed sowing rate is determined. Wheat that has a high 1000 grain weight also has a higher germination energy, so this is considered one of the most important agronomic properties for farmers. The highest weight was recorded by the cultivar "Pobeda," while the lowest absolute weight was recorded by the cultivar "Euclide" [Table 3]. The overall average in terms of the weight of 1000 grains was 54.80 g. Even Fjell et al. [28] achieved similar results according to which the weight of 1000 grains and the yield are related in close locations, making the soil composition and the climatic conditions the main factors affecting these parameters.

In the milling industry, the determination of hectoliter weight is of great importance. Unsuitable climatic conditions and improper storage conditions affect the reduction of this parameter [29]. "Pobeda" cultivar had the highest hectoliter weight, while the "Europe" cultivar had the lowest hectoliter weight. The results suggest that the "Pobeda" cultivar exhibits superior resistance to various weather conditions, as

Table 3: Evaluation of the main agronomic parameters of wheat cultivars.

Cultivars	Yield (g/m^2)	1000 Grain Weight (g)	Hectoliter Weight (kg/hL)
Euclide	588.97^a	54.10^a	85.45^a
Europe	685.23^a	54.97^a	84.67^a
Pobeda	606.10^a	55.33^a	85.83^a

Means with different superscripts in the same column are significantly different ($p < 0.05$).

Table 4: Determining quality parameters of wheat crops.

Cultivars	Grain Size (%)				Flour Extraction (%)	Hagberg Falling Number (s)
	2.8 mm	2.5 mm	2.2 mm	2.0 mm		
Euclide	82.17[a]	14.50[a]	2.77[a]	0.53[a]	42.97[a]	310.00[a]
Europe	52.67[a]	36.10[a]	9.83[a]	1.27[a]	42.37[a]	332.33[a]
Pobeda	66.60[a]	23.83[a]	8.07[a]	1.37[a]	40.90[a]	275.00[a]

Means with different superscripts in the same column are significantly different ($p < 0.05$).

evidenced by its higher hectoliter weight compared to other cultivars. This characteristic indicates that "Pobeda" may possess genetic traits or physiological mechanisms that contribute to its ability to withstand environmental stresses and maintain grain quality under varying weather conditions. According to Atanasova et al. [30], the "Pobeda" cultivar stands out as a reliable choice, demonstrating unwavering performance and consistent quality attributes, thus proving its suitability for cultivation in various environmental settings. However, other studies mention different wheat cultivars that have shown high hectoliter weight values, indicating that it would be valuable to evaluate other cultivars as well in this region such as Cham-6 and Alex [31,32]. However, in general, the three cultivars had a high average, where the overall average in terms of hectoliter weight was 85.31 kg/hL.

Another important agronomic parameter in wheat is the size of the grains, as this can determine the amount of flour extracted and the germinating energy of the seed. According to ANOVA, it was found that for grain sizes over 2.8 mm and over 2.5 mm, there were significant differences between all cultivars ($p < 0.05$), and for grain sizes over 2.2 mm, significant differences were recorded between the cultivar "Euclide" and two other cultivars "Europe" and "Pobeda," while for grain sizes below 2.0 mm, no significant differences have appeared between the studied cultivars ($p > 0.05$). Tukey's test showed that cultivar "Euclide" had the highest percentage of grains with a size greater than 2.8 mm, while cultivar "Europa" had the lowest, and the average value was marked by the cultivar "Pobeda," while with a grain size greater than 2.5 mm it stands out that the cultivar "Europa" has the highest participation, while the cultivar "Euclide" has the lowest participation [Table 4]. The decrease in the number of grains with this size may be due to the planting density, which consequently also affects the reduced number of grains per row and per plant, which is in agreement with Mtyobile's findings [33]. With grain sizes over 2.2 mm, the cultivar "Europe" and the cultivar "Pobeda" had the highest percentages, while the cultivar "Euclide" had the lowest percentages. The participation of grains with a size below 2.0 mm was similar in all cultivars, but "Pobeda" and "Europe" cultivars were distinguished, which had higher percentages, while the lowest percentage was recorded for "Euclide" cultivar.

3.2. Quality Parameters

No significant differences were observed between the cultivars ($p > 0.05$) regarding the degree of flour extraction. The "Euclide" cultivar had the highest flour extraction rate, while the "Pobeda" cultivar had the lowest extraction rate. The general average of extracted flour was 42.08%. In general, a high degree of flour extraction is estimated to have not been achieved from the three cultivars included in the research. For falling number, ANOVA shows that there are no significant differences between these cultivars. "Europe" is the cultivar that recorded the highest falling number, and the "Pobeda" cultivar had the lowest falling number. In general, we can conclude that in all three cases there was low activity of the α-amylase enzyme, especially in the cultivar "Europe." Similarly, Kiszonas et al. [34] achieved similar results in which different cultivars analyzed have not shown big differences in the value of the falling number, although the rain conditions were different. The observed correlation between flour extraction and falling numbers, key indicators in wheat assessment, uncovers a significant relationship that sheds light on grain quality and its implications on baking. Our analysis reveals a notable positive correlation ($r = 0.77$) between these variables, indicating that higher flour extraction values align with increased falling numbers, suggesting decreased α-amylase activity within wheat grains. This connection underscores the potential of wheat varieties that produce higher flour extraction rates to exhibit reduced α-amylase levels, thus improving dough handling and overall baking quality. Reduced α-amylase activity in wheat grains improves flour extraction by improving milling efficiency and minimizing enzymatic starch degradation, resulting in higher extraction rates. These findings not only underscore the intricate interplay between flour extraction, falling number, and α-amylase activity, but also provide actionable insights for stakeholders in the wheat and baking industries, guiding decisions related to grain selection and processing methods to optimize product quality and sustainability in wheat production and processing practices. In line with our findings, previous research, such as Kiszonas et al. [34], similarly demonstrated that higher falling numbers are associated with lower α-amylase activity and improved soft wheat end use quality.

3.3. Chemical Composition

For the parameters analyzed with NIRS, ANOVA test showed that there are no significant differences between the cultivars analyzed in starch, protein, moisture, and ash content. "Euclide" cultivar had the highest starch content, while the "Europe" cultivar had the lowest. Overall, the average starch content for the three cultivars was 75.46%. This order changed when the protein content was analyzed, where cultivars "Europe" and "Euclide" had the highest protein content, whereas cultivar "Pobeda" had the lowest content. The overall average protein content was 11.04%, which is considered a sufficiently good result. These variations in the nutrient composition among wheat cultivars have significant implications for product quality and consumer preferences in the baking industry. For instance, the higher starch content in the "Euclide" cultivar may result in bread with a softer texture and finer crumb structure, appealing to consumers who prefer lighter and fluffier bread varieties. According to Kharana and Sharma [35], starch is pivotal in bread, providing energy and structure, with its properties including gelatinization and retrogradation. Conversely, the "Pobeda" cultivar, with its higher protein content, may produce bread with a denser texture and chewier crumb.

"Euclide" cultivar turned out to have the highest moisture content, followed by "Pobeda" cultivar, while "Europa" cultivar had the lowest content [Figure 1]. The overall average moisture content was 11.97%. Very similar values were also reached for the ash content, where "Euclide" and "Europe" cultivars were distinguished by higher ash content for a very small difference from the "Pobeda" cultivar. Ash is an important parameter in the bakery processing industry, as the overall mineral content provides insight into the color of the final product. Even Laze et al. [36] have achieved similar results, where the ash content was between 1.45 and 1.88%.

However, in addition to these parameters, it was also possible to analyze the fat and fiber content, where significant differences appeared between the cultivars investigated. Cultivar "Pobeda" had the highest fat content, followed by cultivar "Euclide," while cultivar

"Europe" had the lowest fat content. The overall average fat content was 2.39%. In recent years, considerable attention has been paid to the role of dietary fibers in general health, especially the health of the digestive system, diabetes, cardiovascular diseases, and some types of cancer, which have become part of the modern world. For this purpose, the enrichment of baked foods with fiber was used to increase their effect on health [37]. In terms of fiber content, significant differences appeared between the "Pobeda" cultivar and the other two cultivars. Cultivar "Pobeda" stood out with the highest fiber content, while the other two cultivars reached similar values. Overall, the average fiber content was 2.83%.

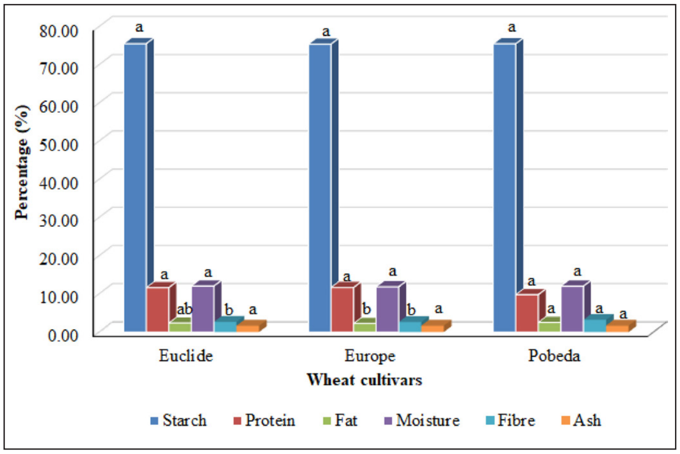

Figure 1: Chemical composition of wheat cultivars. Means with different superscripts are significantly different ($p < 0.05$).

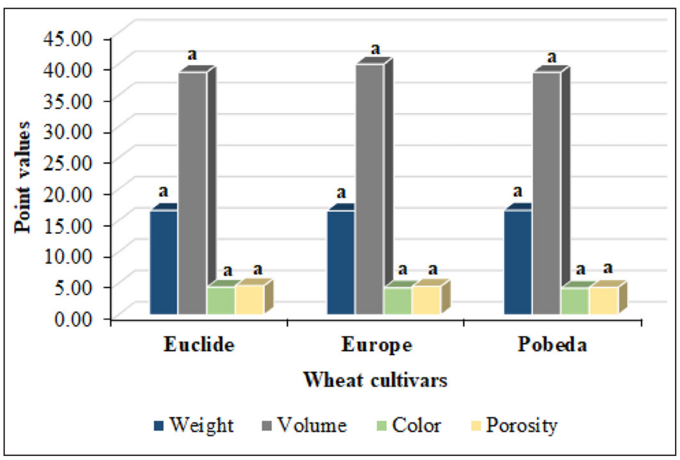

Figure 2: Baking test parameters of different wheat cultivars. Means with different superscripts are significantly different ($p < 0.05$).

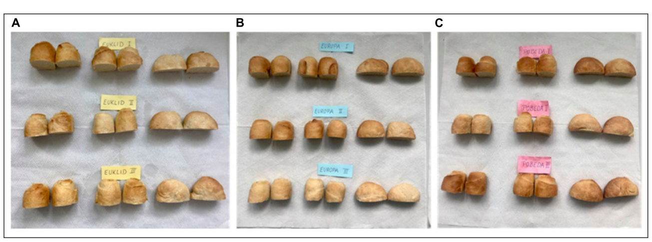

Figure 3: Bread samples from baking tests of Euclide **(A)**, Europe **(B)**, and Pobeda **(C)** wheat cultivars.

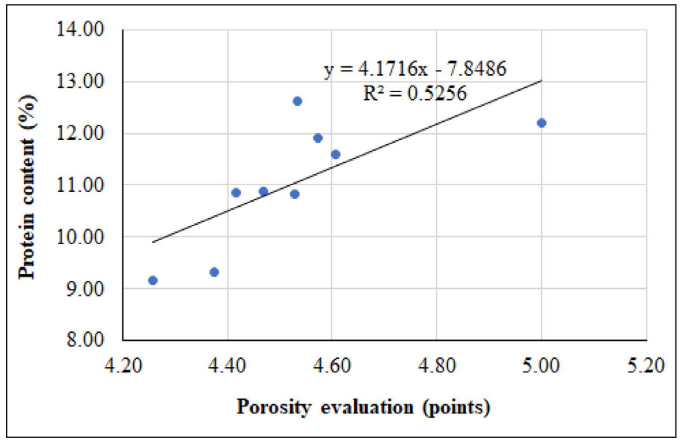

Figure 4: Correlation between protein content and bread porosity.

3.4. Microscale Baking Test

Based on statistical analysis, it was observed that there are no significant differences between the investigated cultivars in the bread baking test. This can be attributed to the results of agronomic and qualitative parameters, which showed no significant differences ($p > 0.05$). However, the bread of cultivar "Pobeda" recorded the largest weight, while the bread of cultivar "Europe" recorded the lowest weight [Figure 2].

The largest volume was recorded for the bread from the "Europe" cultivar, while the breads from the other two cultivars had almost the same values. The observed trend of larger bread volume in "Europe" cultivar compared to the other two cultivars could potentially be attributed to its higher protein content. Proteins play a crucial role in dough development and bread structure, contributing to increased volume and improved texture. The study by Park et al. [38] demonstrates a positive correlation between flour protein content and bread volume, highlighting the significant contributions of proteins to enhanced loaf volume. Additionally, low α-amylase did not influence the volume parameters of cultivars. Therefore, the "Europe" cultivar recorded the highest volume, which agrees with the findings of Rakita et al. [39], who stated a negative correlation between α-amylase and bread volume. Very similar values were also reached in the scoring of bread's color, where the bread from cultivar "Euclide" was distinguished as the best [Figure 3]. The same scoring order was also achieved in the evaluation of the porosity of breads, where cultivar "Euclide" was evaluated more for the porosity of its bread with 4.66 points. The observed trend of higher color and porosity scores in the "Euclide" cultivar suggests that it may be the preferred choice in terms of overall bread quality and aesthetic appeal. In further exploring the observed variations in agronomic and quality parameters among the cultivars, our analysis suggests a complex interplay of genetic traits, environmental factors, and cultivation practices influencing wheat performance. While our study focused on three prominent cultivars in Kosovo, a more nuanced understanding of these variations necessitates comparisons with a broader range of cultivars and studies. Genetic differences among cultivars may contribute to variations in yield, grain size, and quality traits, highlighting the importance of cultivar selection in optimizing agricultural outcomes. Additionally, environmental conditions, including soil composition and microclimates, may exert significant influences on cultivar performance, warranting further investigation. By contextualizing our findings within the broader body of research, we aim to contribute to a more comprehensive understanding of wheat cultivation dynamics and quality attributes, facilitating informed decision-making for farmers and stakeholders in the agricultural and baking industries.

A strong positive correlation was observed between the evaluation of the porosity of bread and the protein content in the cultivars included in the research [Figure 4]. The increased protein content in wheat, particularly gluten, plays a crucial role in forming a flexible network within the bread's structure, trapping the CO_2 gas generated during fermentation, thus contributing to the bread's texture and volume. These results are compatible with those achieved by Aamodt et al. [40], who have shown that proteins have a direct impact on increasing the quality and corresponding characteristics of bread, but here the quality of proteins in addition to their quantity should be taken into account.

4. CONCLUSION

Comprehensive research on the three wheat cultivars, namely, "Euclide," "Europe," and "Pobeda," revealed several important insights into their agronomic and quality characteristics. Even though ANOVA results did not indicate significant differences in yield parameters, weight of 1000 grains, and hectoliter weight, the individual performance of cultivars was of particular interest. "Europe" exhibited the highest yield, while "Euclide" recorded the lowest. On the other hand, the weight of 1000 grains, a critical factor in determining seed sowing rate and germination energy, and hectoliter weight, crucial in the milling industry, showcased "Pobeda" with the highest weight. Grain size analysis unveiled significant differences, with "Euclide" showing the highest percentage of grains over 2.8 mm. Flour extraction rates were similar among cultivars, with "Euclide" achieving the highest and "Pobeda" the lowest. Chemical composition analyzed with NIRS revealed significant differences in the fat and fiber content, with "Pobeda" exhibiting the highest fat and fiber content. Baking tests demonstrated no significant differences in bread characteristics, and "Euclide" showed better results in terms of color and porosity. The findings of this research make us understand that the cultivar "Euclide" has shown the best characteristics for cultivation, especially for quality parameters and properties in processed products, followed by the cultivar "Pobeda" with the best properties for agronomic parameters. Cultivar "Europe" showed the weakest properties for most of the analyzed parameters. These findings collectively emphasize the influence of cultivar-specific traits on various agronomic and quality parameters, providing valuable information to farmers and the baking industry. Farmers in Kosovo can utilize the insights from this study to inform their decisions when selecting wheat cultivars, considering the specific requirements of their intended end use, while the bakery industry can take advantage of these findings to assess and identify the most suitable cultivar for bread production, thus improving product quality and meeting consumer preferences more effectively. More research is essential to encompass a broader spectrum of wheat cultivars and diverse geographical regions, allowing a more comprehensive understanding of wheat cultivation dynamics and quality attributes.

4.1. Limitations

While our study offers valuable insights into the agronomic and quality parameters of three wheat cultivars in Kosovo, it is important to recognize its limitations. First, the analysis was confined to a select group of cultivars, which may restrict the applicability of our findings to other wheat varieties grown in different regions. Moreover, our study concentrated on a specific geographical location within Kosovo, potentially overlooking variations in agronomic and quality parameters that could arise in diverse environments. Factors such as soil composition and microclimates could introduce variability in cultivar performance. Additionally, the limited sample size of the selected cultivars raises concerns about the representativeness of our findings for the broader wheat-growing community. While these cultivars were chosen based on their prominence in local agricultural practices, the restricted diversity in cultivar selection may limit the breadth of our conclusions. Acknowledging these limitations is crucial for ensuring the credibility and applicability of our findings. It prompts us to consider the potential impact of these constraints on the interpretation of results and the subsequent implementation of practices by farmers and stakeholders in the baking industry. For instance, farmers may benefit from understanding that the performance of these cultivars might differ significantly when grown in other regions with different soil types and climatic conditions. Similarly, stakeholders in the baking industry should be aware that the quality parameters observed in this study may not be universally applicable to wheat sourced from other locations. Future research endeavors can aim to address these limitations by encompassing a wider range of wheat cultivars and diverse geographical regions, ultimately contributing to more robust and generalizable conclusions.

5. AUTHORS' CONTRIBUTIONS

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work. All the authors are eligible to be an author as per the international committee of medical journal editors (ICMJE) requirements/guidelines.

6. FINANCIAL SUPPORT AND SPONSORSHIP

The author declares that no funds, grants, or other support were received during the preparation of this manuscript.

7. CONFLICT OF INTEREST

The author report no financial or any other conflicts of interest in this work.

8. ETHICAL APPROVALS

This study does not involve experiments on animals or human subjects.

9. DATA AVAILABILITY

All the data is available with the authors and shall be provided upon request.

10. USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

11. PUBLISHER'S NOTE

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How to cite this article:
Gashi N. Comprehensive evaluation of agronomic and qualitative characteristics in selected wheat cultivars in Kosovo.
J App Biol Biotech. 2024. http://doi.org/10.7324/JABB.2024.189470