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Triticale, a Grain with Many Uses, Including Medicinal

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Abstract: Triticale (*Triticosecale* Wittmack) are the result of crossing, having as parents *Triticum aestivum* and *Secale cereale*, taking from them a high production capacity and an adaptability and resistance to biotic and abiotic stress factors. Depending on the author, they have a protein content between 10 and 22%, a starch content of around 60% and a lysine content higher than wheat. They are used in different industries in different forms. In medicine, they have a preventive role against metabolic tubulation, cancer and an anti-inflammatory role. It is used in the bakery industry, the manufacture of pastries, biscuits, in different concentrations together with wheat flour, in the beer, cellulose, bioethanol, food industry, in fish grain and even in the manufacture of ecological polymer materials.

Keywords*:* protein, starch, triticale, use.

Introduction

Triticale (*Triticosecale* Wittmack) is the result of human-controlled crossing of the genus *Triticum aestivum* and the genus *Secale cereale* (Miller, 1987). Through the genetic combination of the two cereal species they took on certain characters, namely: the high production capacity and a high protein content, inherited from wheat, and the high adaptability and resistance to biotic and abiotic stress factors, and a high lysine content from rye (Gaşpar and Reichbuch, 1978). In the 1970s, two main groups of triticale were discussed. Octoploid triticales, which were amphiploids of hybrids between hexaploid wheat and rye, and hexaploid triticales, which were

amphiploids of hybrids between tetraploid wheat and rye. The greatest impact on the development of this new species was made by those from the National Center for the Improvement of Maize and Wheat in Mexico City, Mexico (CIMMYT). They initiated international triticale testing programs throughout the world (Zillinsky, 1974). Recently, in addition to the two important groups of triticale, a new group was obtained, namely the tetraploid triticale, which come from crossing hexaploid wheat with diploid rye, and then the F1 forms self-pollinate. Among these three groups, the most successful are the hexaploid triticale, they have a high production capacity, a stability of characters over time, show a good resistance to diseases, wintering, drought and fall. But, from the point of view of bakery properties, the octoploid forms are the most suitable for this industry, having in the genetic component, the D genome, taken from *Triticum durum* (Muntean et al., 2014). The protein content is between that of wheat and that of rye, and it differs from one author to another. In 1973-1975, 7 triticale varieties, one recommended wheat variety and one rye variety were tested in the southeastern United States of America. After testing the 9 varieties of cereals, it was found that the average protein content of triticale was 14.4%, compared to wheat which had 13.7% and rye which had 13.2% (Bishnoi and Hughes, 1979). The protein substances of triticale vary between 10.2 and 19.4% (Gașpar and Reichbuch, 1978). Lorenz and Pomeranz (2009) described in an article that their protein content is between 12 and 22%. Depending on the variety, they can have a protein content between 11 and 14% (Heger and Eggum, 1991). According to Fraś et al. (2016), triticale has a protein content between 11.4 and 14%, and besides protein, triticale has a higher lysine content (0.33-0.71%) than wheat. It is certain from all the research carried out that the protein content of triticale is between that of wheat and that of rye (Starodub, 2008).

Spread

According to the data published by Faostat, in 2021, the total area cultivated with triticale around the world was 3,830,794 hectares. Of the 3.8 million hectares, the largest area was cultivated in Europe (3,356,872 hectares), followed by Asia, where 288,115 hectares were cultivated. Oceania (96,207 hectares) ranks third in the

world in terms of area cultivated with triticale in 2021. Due to the difficult cultivation conditions, the smallest area with triticale was cultivated in Africa (10,379 hectares).

In 2021, the largest triticale grower in Europe, and in the world, was Poland (1,281,600 hectares). The second place in the world and in Europe was occupied by Belarus, which cultivated an area of 513,270 hectares, followed by Germany with 328,300 hectares.

Romania, in 2021, planted an area of 64,550 hectares and obtained a total production of 259,210 tons, with an average production per hectare of 4015 kg.

Chemical composition

In India, a comparative study was done between 14 triticale genotypes and 2 genotypes cultivated under similar culture conditions. In triticale, the recorded protein content was 13.1%. From this study they found a poor quality of gluten compared to wheat, the energy value was 1486 kj/100g) (Sehgal et al., 1983) (Table 1).

The chemical composition of triticale differs depending on the variety, the cultivation area and the author. In Sweden, where 80 triticale samples were studied, the average of the samples was 66.5% starch and 11.7% protein content (Pettersson and Aman, 1987) (Table 1).

In addition to the winter triticale varieties, through the improvement of this new cereal species, spring triticale varieties were created which, according to Peña (2004), have a richer chemical composition of the grains compared to the autumn varieties. But the winter varieties have a higher free sugar and ash content than the spring varieties (Table 1).

According to Starodub (2008), triticale has a crude protein content of 14.2% and a starch content of 62%. In addition to these, they also contain various amino acids, including lysine, tryptophan, cystine, alanine, etc. (Table 1).

The protein content of triticale grains is between 7.5 and 15.2%, which is similar to that of wheat. Compared to wheat, triticale has a higher content of lysine, which is a limiting amino acid in cereals. Average crude fat is 1.2% DM. They have a higher content of lysine, arginine, aspartic acid and alanine than wheat. The starch

content of triticale grains is similar to that of wheat grains (60, 61, respectively 54) (Biel et al., 2020) (Table 1).

The lysine content according to Biel et al., (2020) of triticale is 2.56 (g/16 g N), and the content in mineral substances (kg DM) is 3.85 phosphorus, 0.17 sodium, 0.4 calcium and 1.1 magnesium. The content of the grains in microelements (mg) is 25 zinc, 37 iron, 3.4 copper and 26 manganese. Besides all these, triticale grains also contain β-glucan, which is a major carbohydrate in the cell wall. This carbohydrate is a polysaccharide composed entirely of glucose units, which are linked together by a polymer chain. This carbohydrate has the property of lowering cholesterol and cancer protection potential, besides all this, β-glucans can be useful in controlling the level of glucose in the blood. The β-glucan content of triticale grains is 0.5-1.1% (Biel et al., 2020) (Table 1).

Triticale used in medicine

Triticale has fewer uses in medicine due to the fact that it was created by crossing wheat with rye, taking from the two high production capacity, high protein content and great ability to adapt to climatic conditions and good resistance to foliar diseases.

At the same time, research is being done on the introduction of triticale in human medicine. By carrying out a study in Latvia, the presence of lunasin peptide in triticale was discovered. This new peptide has a preventive role on cancer, anti-inflammatory conditions and cholesterol reduction. Initially, it was believed that this peptide is present in soy, barley, wheat and rye. According to the study, triticale is the richest cereal in lunasin, namely 6.46 mg/g in genotype 0002-26 (Nakurte et al., 2012).

Triticale grains have a rich content of natural phytochemical substances, among which the most significant substances are phenolic acids. They are found in flour and bran. Following a study, it was found that the largest amount of phenolic acids was found in bran. Phenolic acids have an antioxidant, anticancer, antibacterial, cardioprotective role and contain anti-inflammatory agents that stimulate the immune system and smooth the skin (Jańczak-Pieniążek et al., 2023).

Tabel 1

Chemical composition of triticale according to different authors

Substance	after Sehgal et. al., 1983 (%)	after Petterson and Aman, 1987 (%)	after Peña 2004		after Starodub, 2008			after Biel et. al., 2020 (g/kg DM)
			Spring triticale (%)	Winter triticale (%)	Content (%)	Amino	Content (%)	
Protein	13.1	11.7	10.3-15.6	10.2-13.5	14.2	Lysine	3.44	95
Ash	1.83	1.8	1.4-2.0	1.8-2.9	2.0	Tryptophan	1.03	13
Total fibre	-	13.3	-	-	-	Cystine	3.38	-
Crude fibre	2.37	-	3.1-4.5	2.3-3.0	-	Cystidine	1.49	10
Free sugar	-	4.6	3.7-5.2	4.3-7.9	-	Tyrosine	1.31	-
Crude fat	-	2.2	-	-	1.6	Alanine	4.08	12
Starch	-	66.5	57-65	53-63	62.0	-	-	-
Total carbohydrates	-	-	-	-	-	-	-	870
Lipides	2.65	-	-	-	-	-	-	-
Ether extract	-	-	1.5-5.4	1.1-1.9	-	-	-	-

Latvian researchers were the first to discover the presence of lunasin in triticale (Muceniece, 2016).
Another study conducted on eighteen healthy subjects (7 men and 11 women) brought growing evidence that the consumption of triticale flakes protects against metabolic disorders. Triticale flakes were administered to these subjects in order to observe glycemic and insulinemic responses. Their plasma glucose and serum insulin were measured for 120 minutes, and it was found that triticale flakes induced a smaller insulin response and a more stable insulin concentration. After completing this study, it was found that triticale flakes can be beneficial for the prevention and treatment of metabolic disorders (Meija et al., 2019).

A study was carried out that evaluated the anti-inflammatory properties of several vegetable lignans, which are most commonly found in food. In this study, the anti-inflammatory effects of these lignans on human aortic endothelial cells treated with tumour necrosis factor were investigated. Among the lignans studied were HMR and HMR2, which is dominant in cereals, including triticale, and these showed strong anti-inflammatory properties in endothelial cells, at least partially, by attenuating nuclear factor B and phosphorylation of signal-regulated kinase extracellular (Spilioti et al., 2014).

Studies have also been carried out using ethyl acetate and ethanol extracts obtained from several varieties of straw cereals, including triticale, in order to investigate their antioxidant effects. Unfortunately, all extracts were ineffective in cholinesterase inhibition tests and had weak or moderate activity in antioxidant tests. Triticale extracts showed a higher activity in the power reduction experiments (Senol et al., 2012).

Triticale used in the bakery industry

Due to its chemical composition, which is similar to that of wheat, triticale was gradually introduced into the bakery industry. Their only disadvantage is their low gluten content and high alpha-amylase activity, which gives them poor baking properties, at least not in proportion to 100% triticale flour (Galoburda et al., 2020).

Studies have been carried out on the dynamics of volatile compounds in triticale flour dough. A dough obtained from triticale

flour and a dough prepared using cultures based on *Lactobacillus sanfranciscensis* were studied. For that study, 3 types of dough were used, triticale mixture, triticale mixture + ready-to-use dough and triticale flour mixture bread with two-stage dough, the latter containing the Bacillus genus bacteria culture . The results obtained showed that the use of fermenting bacteria resulted in obtaining a wide spectrum of volatile compounds, the bread having a pronounced aroma (Galoburda et al., 2020). From here it follows that by introducing some fermenting bacteria into the composition of the dough, we can obtain bread from triticale flour similar to that obtained from wheat flour.

Triticale flour is also used in the biscuit industry. The best performing lines and varieties of triticale close to those of wheat from CIMMYT were studied, they were sown manually in experimental plots of 3 m2. It was shown that 4 of the 10 varieties and lines studied are suitable for the manufacture of biscuits. Although the biscuits obtained have a high percentage of prolamin and low glutenin. The relationship between the two will become a selection criterion in the manufacture of biscuits. Also, AWRC is not as efficient as the one obtained from wheat, but the obtained results can demonstrate that the manufacture of biscuits from triticale flour can become an alternative in the future (Leon et al., 1996).

A comparative study was carried out in obtaining layered cakes from rye, wheat and triticale flour, after baking the layered cakes, those obtained from triticale flour and wheat flour were similar (Bonastre et al., 2010).

The quality of the bread generally depends on the variety chosen. Out of 11 varieties of triticale grown in the region of Khorezm, 3 of them had high levels of bread quality and organoleptic characteristics such as colour, shape, bread structure, elasticity, taste and core porosity. In the present study, flour bread was prepared in 3 portions, 20% triticale-80% wheat, 50/50 and 100% triticale flour (Doschanov et al., 2021).

In Australia, genetic progress is being made in triticale, 17 varieties were tested in four culture environments over a period of 2 years. The obtained production was ground on the mill with hammers and then followed a series of analyses on wholemeal flour, among which amylase activity, almond content, flour colour, etc. It was also found that some varieties have waxy properties, suitable for the

production of noodles. At the same time, it is believed that breadmaking indices are also given by cultivation technology, namely by fertilization (Pattison, 2013).

Due to the properties of triticale grains, they can also be used for technological purposes, not only as fodder, including: milling, confectionery, bakery and pasta production. In Poland, triticale flour was used in the use of pastries and biscuits even in percentage of 100% triticale flour, and satisfactory results were obtained. But for the full use of this grain, certain technological changes are necessary (Haber and Lewczuk, 1988).

Triticale used in the beer industry

Triticale grains are also used for other purposes. Besides animal feeding and the bakery industry, they are also used in the alcoholic beverage industry, and one of these industries is the beer industry. The malt used for brewing beer was tested in different reports. In relation to 0, 30, 50, 70, 100% triticale. It has been proven that the best ratio for obtaining beer is 30/70, i.e. 30% triticale malt and 70% barley malt (Ambriz-Vidal et al., 2019).

A comparative study was also carried out, the use of triticale and adjuvants commonly used in beer production (brewing rice, barley or corn), beer production was carried out using several ratios 0, 25, 50, 70% supplemented with enzymes . It was proven that the addition of 25% triticale to the beer malt increased the viscosity of the wort by 10% and decreased the filtration capacity by 12%. Referring to the commercial aspect, the use of triticale in brewing has brought significant savings in the recovery of the extract compared to those of the usual additives, thus triticale is very suitable as an adjuvant in brewing (Glatthar et al. 2003).

A recent study was conducted that analysed several modern triticale lines, specifically 10 triticale lines, these lines came from CIMMYT, Mexico. Grain samples were taken, as many as three samples from each line, and grain quality analyses were made, determining the ash, protein, fiber, fat and carbohydrate content. Most of the triticale lines were very stable, and had the right percentage of protein and carbohydrates for their use in the beer industry. Triticale malts were of high enough quality to be used in the brewing industry. But the big brewers are not satisfied with the high

viscosity values in the wort, because the final beer can have a slight turbidity. This could be the only problem presented by triticale grains in the beer industry, but studies are being done for its introduction in the craft beer industry, where the taste and turbidity could be accepted (Guzmán-Ortíz et al., 2018).

In an experiment that took place in Serbia, the Obyssey triticale variety was used, which was used to obtain the must. This variety was the substitute for barley malt. Experiments were made to produce must with and without the addition of the commercial enzyme Ultraflo Max, of Danish origin. Triticale was added in different proportions to obtain malt: 0, 10, 20, 30, 40, 50, 60, 70 and 80. From the obtained results it was found that the Obyssey variety can be used as a substitute for malt up to 60% without the commercial enzyme Ultraflo Max is added. If this enzyme is added, it can be used as a malt substitute up to 80%. The increase in triticale content led to an increase in must viscosity. The analytical results of the wort produced from this variety of triticale showed good parameters for use in the beer industry (Grujić et al., 2010).

Triticale used in human nutrition

Due to the increase in the world's population, the need for food is increasing, so agricultural producers must ensure high production. An important and efficient source of food in the human diet are seedlings, including triticale seedlings, which have a high content of vitamins, antioxidants, enzymes and microelements (Zhukov et al., 2021).

In a study that involved the introduction of triticale bran into yogurt at a maximum concentration of 4%, it was found that after 7 days of cold storage, the number of bacteria in the yogurt increased, and until the end of the storage period (28 days) a high number of viable bacteria was maintained compared to the control sample. Polysaccharide extracts from triticale bran recorded a strong antioxidant activity, from which it follows that triticale bran is a new probiotic and antioxidant source (Agil and Hosseinian, 2012).

Since they have a low gluten content, triticale flour cannot be used in 100% proportion in the manufacture of bread. But, from a nutritional point of view, triticale is rich in essential amino acids, mineral compounds and dietary fibers (Biel et al., 2020).

Thanks to the endogenous enzymes that triticale grains possess, they can be used as a natural sweetener in the manufacture of triticale and wheat flour cakes. The sweetness of the cookies is due to the alpha-amylase activity and the resting time and temperature of the dough. Sensory senses I preferred the cakes that were obtained from a dough that stayed for 25 minutes at a temperature of 65 degrees Celsius (Arizmenndi-Cotero et al., 2020).

Studies have been carried out on the properties of triticale grains, which have high levels of essential and non-essential amino acids. Due to the content of the grains, they are one of the future raw materials in obtaining expanded grains for the sugar industry. The best organoleptic properties of the expanded beans were obtained at a roasting time of 7 minutes, a steam pressure of 14 atm and a steam impregnation time of 6 minutes (Racolţa and Salontai, 2000).

Triticale used in other food packaging industry

In a study carried out on the active ingredients of triticale flour, through which bacteriocin-like substances produced by *Enterococcus faecium,* which has an antimicrobial activity against *Listeria innocua* bacteria, were added. These active films maintain antisterility for a period of up to 45 days. From these films, bags were obtained that were heat-sealed and used in the packaging of cheese slices. This study suggested that if these bacteriocin substances are added to the active films of triticale flour, they could be used in the food packaging industry (Salvucci et al., 2019).

Triticale used in other cellulose industries

Due to the high content of vegetable matter, triticale straws are a source of alternative raw material in the manufacture of paper. Research at the laboratory level stated that triticale pulp is equal in quality to recycled pulp from other raw materials (Bates et al., 2020).

Triticale straw contains a considerable amount of lignin and hemicellulose. After digestion and gradual delignification of straw, lignocellulosic nanofibers were obtained, which are used as an additive for paper strength (Tarrés et al., 2017).

Triticale used in the manufacture of plastic materials

Cereal starch is used for the manufacture of ecological polymer materials. Triticale starch is used for the manufacture of plastic products, replacing traditional plastic. In the manufacturing process, the starch is plasticized and gelatinized, bearing the name of thermoplastic starch, which replaces conventional plastic materials. It is mixed with other plastic materials in a molten stage and thus results in homogeneous mixtures that are used in the manufacture of plastic materials (Ton-That and Li, 2015).

Triticale used in the bioethanol industries

Bioethanol is produced by fermenting renewable biomass, and it can be combined with gasoline in certain proportions, besides this, it can significantly replace the use of fossil fuels. Bioethanol is an alternative, ecological energy source. If until now crops containing starch were used to obtain bioethanol, such as rye and wheat, more recently Serbia is trying to increase the production of bioethanol produced from triticale, stating that this plant is suitable for this industry due to its content in starch and sugars (Mojović et al., 2012).

Compared to the chemical composition of triticale grains, they have a high starch content and a high amylolytic enzyme activity, from which it follows that they are ideal for the bioethanol industry, bioethanol being an alternative energy source. Studies have been carried out that consisted in the ultrasonic pretreatment of triticale flour to improve the release of fermentable sugars, thus increasing the yield of bioethanol. Pretreatment with ultrasound increased the content of glucose by 15.71% and maltose by 52.27%, which led to a 10.89% increase in the production of bioethanol produced from triticale flour (Pejin et al. 2011).

In South Africa, short-term attempts are being made to replace 2% of the national liquid fuel supply with biofuel produced from starch-free triticale bran. Triticale is the ideal crop for the climatic conditions of South Africa, and has low requirements for nitrogen. A study was carried out that tried to raise the total yield of ethanol produced in a factory by pre-tarring and enzymatic hydrolysis of triticale tares, which are obtained by grain fractionation and starch separation. This pretreatment method has the effect of removing

sugar recovery so as to maximize the digestibility of triticale bran without starch. By using 0.1% (dry weight/volume) of sulfuric acid at 160°C for 22.5 minutes it could be possible to obtain 245 litres of ethanol from a dry ton of triticale bran without starch (García-Aparicio et al., 2010).

Triticale used in aquaculture

Triticale are an important source of protein and carbohydrates, they have a lower starch content than wheat, but a higher lysine content than wheat, which makes them more easily digestible and more available for absorption in the GIT of fish. A study was carried out in which triticale was introduced into the diet of Nile tilapia (*Oreochromis niloticus*) in percentages of 0, 5, 10, 15 and 20%. The obtained results found that the use of triticale in a proportion of 5-20% in fish feed did not negatively influence the growth performance, blood variability and immunity of Nile tilapia (Dawood et al., 2020).

At an international conference, a paper was presented through which triticale was introduced into the carp diet. The obtained results suggest their potential use in carp (*Cyprinus carp*io) feed by partially replacing wheat flour and corn (Markovic et al., 2013).

Based on an experiment in which wheat was replaced with triticale in the diet of Atlantic salmon (*Salmo salar*), it resulted that the replacement of wheat with triticale in the basic ration did not show any differences in terms of the acceptability of the diet, so these results indicated that triticale can be a nutritional substitute for wheat in the diet of Atlantic salmon (Hughes, 1990).

Conclusions

Triticale is an important source of protein, vitamins, minerals and carbohydrates. These have a higher ash and lysine content than wheat.

Due to the chemical composition of the grains, they are used in various industries.

It is used in medicine due to the lunasin content, which has a preventive role against cancer and an anti-inflammatory effect. The consumption of triticale flakes has a preventive role against metabolic disorders.

Triticale is also used in the bakery industry, in the preparation of bread, layered cakes, cakes and biscuits.

Due to the properties of the grains, it is used in a mixture as malt in the manufacture of beer.

Triticale has a starch content similar to wheat, which makes them used in the manufacture of food packaging.

Together with other cereals, these are also used in human diets in various forms, for example as triticale flakes in yogurt, a natural sweetener in the manufacture of cakes and as expanded cereals in the sugar industry.

Triticale has a high content of starch and lignin, which gives it the property of being used in the cellulose industry and in the manufacture of ecological polymer materials.

Due to the high content of organic matter, triticale is an alternative source in the production of bioethanol.

Having a chemical composition similar to that of wheat, they are used in the food of different species of fish (*Oreochromis niloticus, Salmo salar* and *Cyprinus carpio*).

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