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ASSESSMENT OF COMMON WHEAT QUALITY IN ROMANIA IN THE CONTEXT OF CLIMATE CHANGE - minireview

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Abstract: The study aimed to assess common wheat quality in Romania in the context of climate change to identify adaptation measures and ensure the sustainability of the agri-food system. The negative effects of extreme weather events on cereals are manifested starting from the field by affecting the quantitative and qualitative crop indicators, which leads to the decrease of the trade indicators and, therefore to a potential threat for regional agri-food suppliers. The research put a special emphasis on common wheat grown in agricultural regions with a high risk of contamination with the fungi *Fusarium* spp. and mycotoxin deoxynivalenol. Scientific results will contribute to raising awareness of the climate change effects on the agri-food chain by beneficiaries in scientific research, agricultural production, trade and regulatory authorities. Scientific data are inputs for future projects on the use of artificial intelligence in agriculture and the establishment and/or updating of the risk envelope in the agri-food sector.

Keywords: *wheat indicators, bread wheat quality, risk assessment, climate change*

Common wheat known as bread wheat (*Triticum aestivum*) is used in the baking industry and is grown in areas with subtropical, Mediterranean, oceanic and continental climates (30–60 ^{o}N and 25–40 ^{o}S) (Chen & Chen, 2013; Khadka et al., 2020; Gagiu et al., 2021, 2022; FAO, 2023). From 1961 to 2020, the distribution of average wheat production varied between continents (Asia 38.1%, Europe 36.8%, Americas 19%, Oceania 3.2%, and Africa 2.9%), and the top ten growers were the People's Republic of China, the Former Soviet Union, the United States of America, India, the Russian Federation, France, Canada, Ukraine, Turkey and Australia. In Romania, the cultivation of common wheat contributes to the security and sustainability of the agri-food system, which occupies an important place in the country's economy. In 2020, the area harvested with wheat was 3,042,600 hectares, with a production of 10,297,110 tons and a productivity of 4,891 kg/ha. Due to these wheat harvest indicators, Romania was included in Group I of global producers (production >5,185,500 tons) in 2020 and Group II of producers with an average production ≤10,960,516.07 tons in the period 1961–2020 (FAO, 2023). In 2021, Romania led the list of wheat exporters in the Black Sea area, competing with Ukraine and Russia (Nițu, 2022a, 2022b).

Romania's climate is temperate continental, determined by its geographical position (46 ^{o}N, 25 ^{o}E), the disposition of the Carpathian Mountains and the vicinity of the Black Sea and the Danube River. Additionally, the positioning of the country in the area of intersection of Atlantic, Mediterranean, Pontic, continental and arctic air masses determines a humid climate in Transylvania, a humid-balanced climate in the Southern Hilly Area, a sub-humid climate in the Western Plain and Oltenia Plain, a semi-arid climate in Moldavia and the Southern Plain and an arid climate in Dobrogea (Păltineanu et al., 2007; Gagiu et al., 2022, 2021). From 1901 to 2015, the multiannual average air temperature increased by 0.6°C and the annual

precipitation decreased, especially in the last 30 years with extremely hot, dry or rainy years (Busuioc et al., 2012; Polifronie, 2014; Mateescu, 2016; Covaci et al., 2016; Oprea et al., 2018). Climate change forecasts indicated an increase in air temperature and a decrease in precipitation in the east of the Southern Plain, Oltenia Plain and southern Moldavia, while changes in the Western Plain and sub-Carpathian regions will not be evident (Busuioc et al., 2012).

Climate change leads to the occurrence of weather events that are classified as extreme (heavy precipitation, floods, heatwaves, drought, extratropical or tropical cyclones, frost waves, heavy snowfall, storms, tornadoes, ice or hailstorms) when they have values of meteorological importance, such as low frequency of occurrence, magnitude, temporal duration, spatial scale and multivariate dependencies, and that cause loss of life and economic damages (Stephenson, 2008). The occurrence of extreme weather events leads to significant decreases in wheat productivity (Mäkinen et al., 2018). Projections regarding the effect of global climate change on agriculture foresee a decrease in the productivity of wheat, maize and other nine major crops in the period 2046–2055 compared to the period 1996–2005 (World Bank, 2010). However, global warming by the year 2100 will cause an increase in cultivated areas and wheat crop productivity in regions with a colder climate at present (Canada, the northern United States, Central Asia, northern China, eastern Africa and southern Australia) (NASA, 2021; Gagiu et al., 2022). In Europe, forecasts up to 2050 have shown that drought caused by climate change will reduce crop productivity and short-term water stress during flowering will be the critical factor limiting current productivity potential (Senapati et al., 2021). The increase in air temperature will increase the risk of contamination of wheat with toxigenic fungi of the genus *Fusarium* in Northern and Eastern Europe and with toxigenic fungi of the genera *Aspergillus* and *Penicillium* in Western, Southern and Southeast Europe (Battilani et al., 2016; Gagiu et al., 2021, 2022). This evolution is because chemotypes and species of toxigenic fungi and the appearance of mycotoxins in cereals have a geographical distribution that is correlated with agroclimatic conditions (Pasquali et al., 2016; Gagiu et al., 2018, 2021, 2022).

Depending on the intensity and frequency of extreme weather events, grain harvest indicators are affected, with a negative effect on national and international food safety and security (Horn et al., 2022; Pickson & Boateng, 2022; Long et al., 2022). We recall that global food security is accentuated by the war between Ukraine and Russia, which are two of the top ten wheat growers globally (Ben Hassen & El Bilali, 2022; World Food Programme, 2022; World Grain, 2022; FAO, 2023). Due to climate change, war situations or the occurrence of other critical events, each country must assess its economic fields, realize the risk envelope, make forecasts, and identify and implement measures to prevent and counter the negative effects. Currently, there is a special emphasis on research that uses historical data to carry out complex research and long-term forecasts, which can be used to identify adaptation measures and develop political strategies for the sustainability of the agri-food system (Fusco, 2022; Long et al., 2022; Preiss et al., 2022). It should be noted that affecting food safety and security is a threat to the national security of each country (Näther & Theuvsen, 2012; Puri et al., 2019). Currently, special emphasis is placed on the use of the digital economy, geospatial technologies and artificial intelligence (García-Berná et al., 2020; Weiss et al., 2020; Mathenge et al., 2020; Hara et al., 2021; Vojnov et al., 2022; Elahi et al., 2022; Javaid et al., 2023).

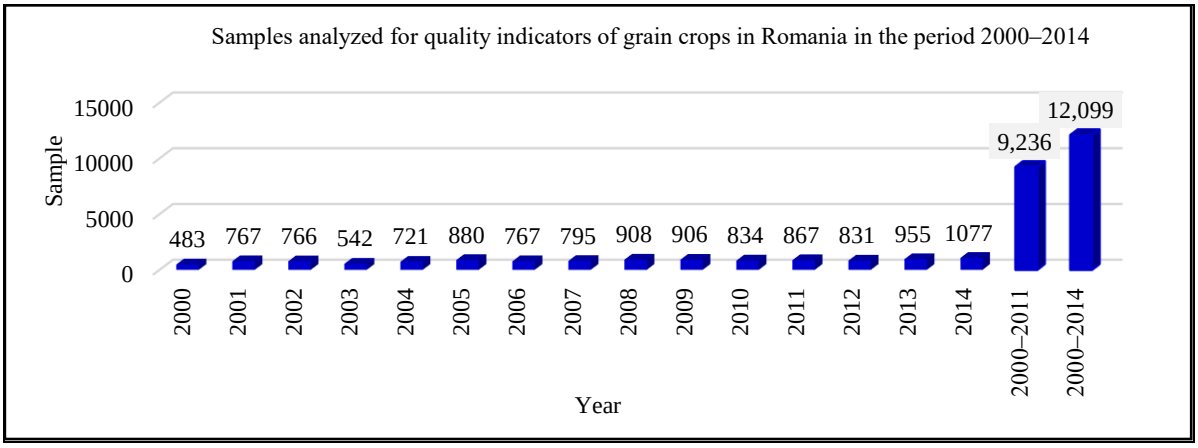
The quality of grain harvests depends on cultivated varieties, applied agricultural technologies, regional agroclimatic conditions and meteorological events recorded each year (Edwards, 2004; West et al., 2012; Schmidt et al., 2016; Góral et al., 2019; Gagiu et al., 2021, 2022). The determination of the selling price at the producer and the marketing of the wheat take place after the crop grading process is carried out based on quantitative and qualitative analyses (ISO, 2007, 2009b, 2009a, 2013, 2019; ICC 1994a, 1994b). The Romanian wheat grading programme includes four grades: I – very good wheat; II – good wheat; III – satisfactory

wheat and IV – unsatisfactory wheat; these represent criteria for establishing the selling price (Tamba-Berehoiu et al., 2012; MADR, 2017; Gagiu et al., 2022). Contamination of wheat crops with toxigenic fungi harms the physico-chemical indicators, the chemical composition of the grain and wheat flour through the degradation of starch and gluten protein fractions, but also on the sensory and technological properties (Wang et al., 2005; Siuda et al., 2010; Eggert et al., 2011; Kreuzberger et al., 2015; Schmidt et al., 2016; Gagiu et al., 2022). To assess the impact of climate change on the quantitative, qualitative and commercial indicators of wheat crops, implicitly on the food and bakery industry, it is necessary to evaluate all the data recorded for as many years as possible, so that risk prevention measures and the sustainability of the agri-food system can be established.

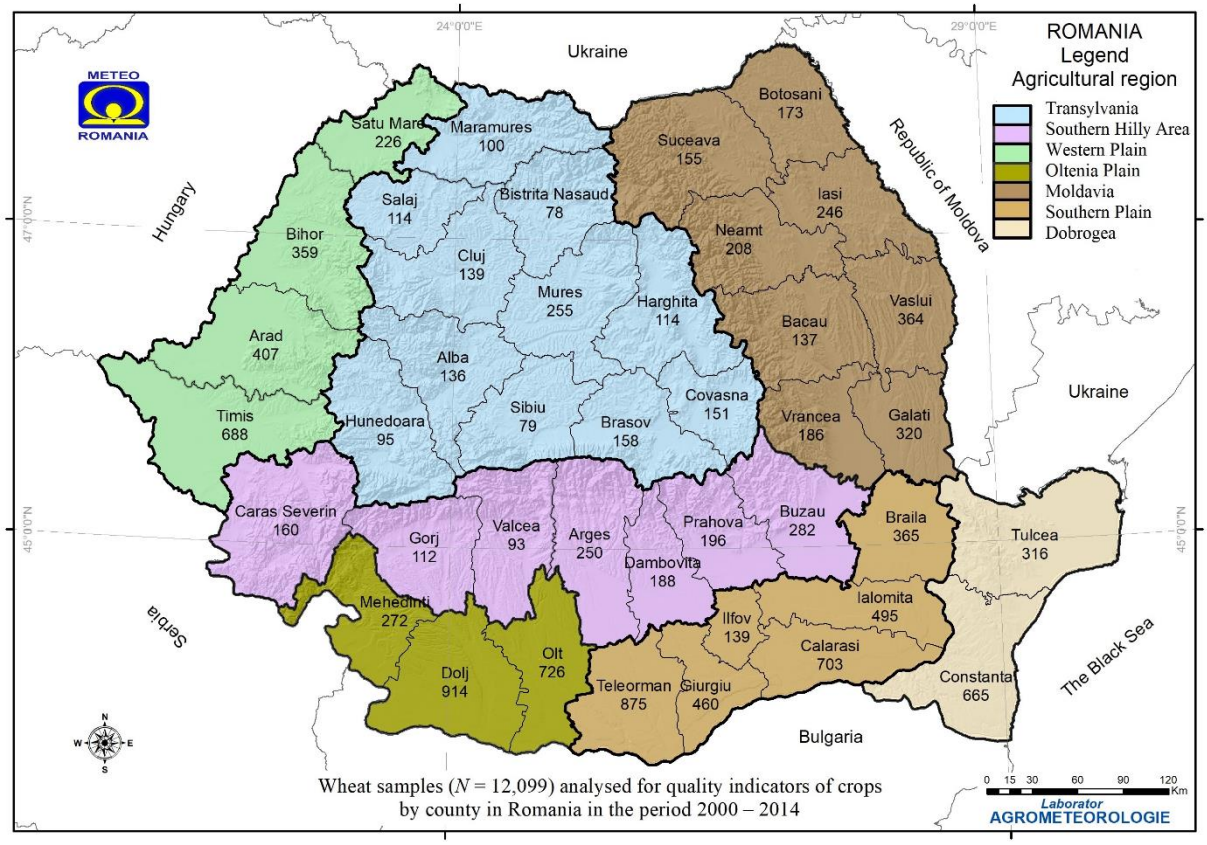
The study aimed to assess the spatial and temporal evolution of the quality of common wheat (bread wheat) in Romania in the context of climate change, to identify adaptation measures and ensure the sustainability of the agri-food system.

The temporal evolution of the quantitative and trade indicators of wheat crops in Romania during 1961–2020 was evaluated in the context of the meteorological conditions recorded in this period. The annual data of the quantitative indicators of the wheat harvests in Romania were imported from the database of the Food and Agriculture Organization of the United Nations (FAO) and used to create a database of IBA Bucharest, which allowed statistical evaluation and temporal evolution assessment. Primary official data on quantitative indicators were reported by the Romanian Ministry of Agriculture to FAO. The data on the evolution of air temperature and precipitation in Romania from 1961 to 2020 were imported from the World Bank Group-Climate Change Knowledge Portal (WBG-CCKP, 2021) and converted from *.csv* format to Excel format which allowed the statistical analysis and temporal evaluations of factors. IBA Bucharest and Meteo-Romania assessed the quantitative and commercial indicators of wheat harvests and meteorological factors in Romania in the period 1961–2020 using Shell/Linux and Fortran/C++ software codes developed for this research. The statistical and temporal analysis of the crop indicators (cultivated area, production and productivity) and trade indicators (export and import – quantity and value) of wheat showed an evolution which was determined by the climatic conditions and extreme weather events (Gagiu et al., 2023). Moreover, these indicators were influenced by the political, economic and social events in Romania and Europe in the period 1961−2020 (Toma et al., 2010; Miron & Lup, 2015; Feher et al., 2017; Zaman & Georgescu, 2018; Mäkinen et al., 2018; Ivașcu & Dănulețiu, 2021; Senapati et al., 2021; OCHA, 2023; Gagiu et al., 2023). The temporal and spatial evolution of qualitative indicators of common wheat harvests in Romania in 2000–2014 was evaluated in the context of the climatic conditions in this period. The annual data of the quality indicators of common wheat were extracted from a total of 12,099 samples (common wheat, durum wheat, triticale and rye) which were analyzed by IBA Bucharest in the Grading Programme in the years 2000–2014 with funding from the Ministry of Agriculture, (Forests) and Rural Development, MA(P)DR (Figure 1) (MAPDR 2000-2009; MADR, 2010-2014;). IBA Bucharest is the MA(P)DR Reference Laboratory for grain analysis, according to Government Decision No. 677 of July 19, 2001, which was updated by Government Decision No. 546 of June 9, 2010 (MAPDR 2000-2009; Romanian Government, 2010; MADR, 2010-2014; Gagiu et al., 2022). The preliminary results showed an annual increase in the areas cultivated with common wheat and the number of wheat samples analyzed, as well as a significant influence of extreme events such as drought and floods on the qualitative indicators of common wheat in the period 2000-2014 (Figure 1) (unpublished data) (MAPDR 2000-2009; MADR, 2010-2014; Bissolli et al., 2011; Green Report, 2011; Schaller *et al*., 2014; Gagiu *et al*., 2021, 2022; WBG-CCKP, 2021; OCHA, 2023). The extensive assessment of the temporal and spatial evolution of the

quantitative, qualitative and trade indicators of wheat harvests in Romania in 1961–2020 in the context of climate change will be published soon (Gagiu et al., 202x).



a)



b)

Figure 1. Distribution of grain samples analyzed for quality indicators of crops in Romania in the period 2000–2014 (*N* = 12,099 samples; common wheat, durum wheat, triticale and rye): **a**) Temporal distribution, **b**) Geographical and spatial distribution.

The historical data regarding the quantitative, qualitative and commercial indicators of wheat harvests in Romania in the years 1961-2020 and 2000-2014 were foreseen to be correlated with the qualitative indicators of wheat and bread obtained from it in the year 2024 to update the climate influence on the agro-food area. The wheat evaluation was foreseen to be

carried out through microbiological, toxicological, physico-chemical and impurity analyses and the weather factors were foreseen will be recorded through the national weather stations. To achieve a correlation with previous studies, a special analysis was mentioned for the localities where common wheat was contaminated with *Fusarium* spp. and deoxynivalenol in the years 2012-2016 (Gagiu et al., 2018, 2021, 2022). Extreme weather events negatively affected the production, productivity and quality of wheat crops, high temperatures and drought led to an increase in protein and starch content, while high precipitation decreased these parameters and increased moisture content with an increase of α-amylase activity; these changes affected the technological baking process and the quality of the bread (Hirano, 1976; Ral et al., 2016; Lama, 2020; Giménez et al., 2021; Poggi et al., 2022; Zahra et al., 2023;). The high gluten content caused a high resistance of the dough and a smaller volume of the bread, which can be improved with baking enzymes or by mixing wheat with special gluten-free cereals (millet, sorghum, buckwheat and amaranth) (Rumler et al., 2023).

The variation of the quantitative and qualitative indicators of common wheat under the influence of current and future climate changes affected the stability of the milling and bakery industry and increased economic uncertainty (Lama, 2020). Therefore, by integrating the historical and current data of the quantitative, qualitative and trade indicators of common wheat, the risk analyses are expected to contribute to the development of the risk envelope in the agri-food sector. Knowing the risk of climate change on crops has facilitated the calculation of financial risks and the purchase of insurance for the sustainability of the agricultural sector (Stojanović et al., 2019; Mare et al., 2022; Dragos et al., 2023;).

The assessment of wheat quality in Romania in the context of climate change contributes to the updating of agri-food technologies and policies, with scientific, technological, economic-social and environmental impacts. The agricultural sector can improve and develop the following adaptation measures and ensure the sustainability of the agri-food system: wheat varieties with superior performance and resistance to climatic conditions and diseases; agricultural technologies according to regional agro-climatic conditions, annually recorded weather events and climate change forecasts; agri-food policies according to scenarios regarding the evolution of the population. A study carried out by the Bill and Melinda Gates Foundation on the global evolution of the population based on fertility, mortality and migration of the inhabitants of 195 countries in the period 2017–2100 showed a decrease in the number of inhabitants in Romania to 7.77 million, but also in Central Europe, Eastern Europe and Western Europe (Vollset et al., 2020). The same study shows that the countries of the Middle East, Central Asia and Africa will register a two- to three-fold increase in population, which means that Romania will be able to increase the export of wheat and other cereals, food and feed if authorities implement measures to prevent the negative effect of climate change at the national level. Between July 2019 and January 2020, Romania's largest wheat exports were made to Egypt, Jordan, Syria, Lebanon, Vietnam and Turkey, which are countries with a significant population growth forecast (G4Media, 2020; Vollset et al., 2020). International organizations and government authorities from all states are involved in the assessment of climate change, trans-border risks resulting from the impact of global climate change, and the adoption and implementation of common measures to prevent and ameliorate negative effects (EEA, 2019, 2021; Arvis et al., 2020; EC, 2022).

The milestones of the research were represented by the creation of databases with crop and trade indicators of wheat in Romania (FAO, 2023), the decennial climate assessment in Romania starting from 1961 until 2020, the acquisition of the main extreme weather events in Romania and Europe from 1961 until now (WBG-CCKP, 2021; OCHA, 2023) and the identification of some political, economic and social factors with a significant impact on the agricultural sector in Romania (Toma et al., 2010; Miron & Lup, 2015; Feher et al., 2017;

Zaman & Georgescu, 2018; Ivașcu & Dănulețiu, 2021; Gagiu et al., 2023). Globally, a multi-expertise approach is required to collect sufficient data to improve knowledge, support tools and resilience of the agri-food system (Battilani & Dall'Asta, 2023). Also, research on the influence of climate change on the production, quality and marketing price of cereals and sustainable food consumption contributes to establishing new trends in the agri-food sector from environmental, economic and social perspectives (Testa et al., 2022).

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