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THE STATE AND DISTRIBUTION OF WATER IN WHEAT GRAINS DURING RIPENING

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Abstract: The process of wheat grain ripening is accompanied by significant physiological and biochemical changes, among which the state and distribution of water play a crucial role. This study investigates the dynamics of water content, its binding forms, and spatial distribution within wheat grains at different stages of maturation. During early developmental stages, grains contain a high proportion of free water, which ensures active metabolic processes, cell division, and nutrient transport. As ripening progresses, the total moisture content decreases, and water gradually transitions into bound forms associated with macromolecules such as proteins, starch, and cell wall components. This shift contributes to structural stabilization and prepares the grain for storage and dormancy. The distribution of water within grain tissues—endosperm, embryo, and outer layers—becomes increasingly heterogeneous, reflecting differences in biochemical composition and metabolic activity. The reduction of free water and increase in bound water are essential for improving grain quality, resistance to mechanical damage, and long-term preservation. Understanding these processes provides important insights for optimizing harvesting time, storage conditions, and processing technologies in agriculture.

Keywords: wheat grain, ripening, water content, bound water, free water, moisture distribution, endosperm, embryo, grain quality

Introduction

Wheat (*Triticum aestivum*) is one of the most important cereal crops in the world, serving as a primary source of food and raw material for various agricultural industries. The formation and maturation of wheat grains involve complex physiological, biochemical, and structural transformations, which directly determine yield, quality, and storage stability. Among the key factors influencing these processes, the state and distribution of water within the grain play a fundamental role[1-18].

During grain development, water is not only a medium for biochemical reactions but also an essential component that regulates metabolic activity, enzyme function, and the transport of nutrients. In the early stages of grain formation, high moisture content ensures intensive biosynthesis of proteins, carbohydrates, and lipids. As the grain approaches maturity, a gradual decrease in water content occurs, accompanied by a transition from free water to more strongly bound forms associated with macromolecules. This transformation is critical for the formation of a stable grain structure and the acquisition of physiological maturity.

The heterogeneous distribution of water across different anatomical parts of the grain—such as the endosperm, embryo, and outer layers—reflects their functional specialization. Changes in water state significantly affect technological properties, including milling quality, germination capacity, and resistance to storage deterioration. Therefore, studying the dynamics of water in wheat grains during ripening is of both theoretical and practical importance.

This study aims to analyze the changes in water state and its distribution during wheat grain ripening and to evaluate their influence on grain quality and post-harvest stability.

Materials and Methods

The present study was carried out using grains of *Triticum aestivum* cultivated under typical field conditions. The objective was to investigate the changes in water state and its distribution during different stages of grain ripening. For this purpose, wheat samples were collected at three key developmental phases: milk stage, dough stage, and full maturity stage. Sampling was performed from several randomly selected plants within the experimental field to ensure representativeness. The collected grains were combined to form composite samples for each stage and immediately transferred into airtight containers to minimize moisture exchange with the environment.

Before analysis, the grain samples were carefully cleaned to remove dust, broken particles, and other impurities. The samples were then sorted based on maturity stage and, when required, manually separated into anatomical components, including the endosperm, embryo, and outer layers (bran). This separation allowed a more detailed investigation of water distribution within different structural parts of the grain.

The total moisture content of the wheat grains was determined using the standard gravimetric method. Approximately 5 g of each sample was weighed with high precision and then dried in a laboratory oven at 105°C until a constant mass was achieved. The loss in weight was attributed to water removal, and the moisture content was calculated as a percentage of the initial mass. This method provided reliable quantitative data on overall water content at each stage of ripening fig-1.

Fig-1. Raining the wheat irrigation

To differentiate between various forms of water within the grain, a combination of thermal and sorption techniques was employed. Thermal analysis was used to evaluate the evaporation behavior of water at different temperature ranges, allowing distinction between free and bound water fractions. Free water was identified as the fraction that evaporates easily at lower temperatures, while bound water required higher energy for removal due to its association with macromolecules such as proteins, starch, and cell wall polysaccharides. In addition, sorption–desorption experiments were conducted under controlled humidity conditions to assess the water-binding capacity of the grain tissues. These experiments enabled classification of water into three main categories: free water, weakly bound water, and strongly bound water.

The spatial distribution of water within wheat grains was studied using a stepwise analytical approach. After initial moisture determination, grains were dissected into their anatomical parts, and each component was analyzed separately for moisture content. This allowed identification of differences in water localization between the endosperm, embryo, and outer layers. Furthermore, microscopic observations were carried out to qualitatively assess tissue hydration and to confirm the heterogeneity of water distribution at different ripening stages.

All experiments were conducted in triplicate to ensure reproducibility and accuracy of the results. Laboratory conditions were maintained at a temperature of 20–25°C and relative humidity of 50–60% to avoid external influences on moisture measurements. The obtained data were processed using standard statistical methods, including calculation of mean values and standard deviations. The results were then organized in tables and graphical forms to facilitate interpretation and comparison between different stages of grain development.

Results and Discussion

The obtained results clearly demonstrate that the process of wheat grain ripening is accompanied by significant changes in both the quantity and state of water. In grains of *Triticum aestivum*, the total moisture content decreased progressively from the milk stage to full maturity. At the milk stage, the grains contained the highest amount of water (up to 60–70%), which is necessary for active physiological processes such as cell division, elongation, and intensive biosynthesis of organic compounds. As the grain developed into the dough stage, the moisture content decreased to approximately 30–40%, indicating a slowdown in metabolic activity and the beginning of structural consolidation. At full maturity, the moisture content further declined to 12–14%, which is optimal for harvesting and long-term storage.

A detailed analysis of water forms revealed a gradual transformation from free water to bound water during the ripening process. In the early stages, free (capillary) water predominated, ensuring high mobility of molecules and active enzymatic reactions. However, as maturation progressed, the proportion of free water significantly decreased, while the content of weakly and strongly bound water increased. This transition is associated with the accumulation of macromolecules such as starch and proteins, which bind water through hydrogen bonding and other intermolecular interactions. The increase in bound water contributes to the stabilization of the grain structure and reduces susceptibility to mechanical damage and microbial spoilage.

The study of water distribution within the grain showed that it is not uniform across different anatomical parts. At early stages, water is relatively evenly distributed; however, as ripening proceeds, a clear gradient is formed. The embryo retains a higher moisture level compared to the endosperm, reflecting its higher metabolic activity and physiological importance for germination. The outer layers (bran) also exhibit relatively higher moisture due to their structural composition and exposure to environmental conditions. In contrast, the endosperm, which serves primarily as a storage tissue, becomes progressively drier as starch accumulation increases.

Microscopic observations supported these findings by revealing changes in tissue hydration and structural density. Cells in the early stages appeared highly hydrated and loosely organized, whereas at later stages they became more compact and dehydrated. This structural transformation is closely linked to the reduction of free water and the formation of a stable, dense matrix of storage substances.

From an applied perspective, these results are highly significant. The reduction of free water and the predominance of bound water at maturity enhance the storage stability of wheat grains and reduce post-harvest losses. Moreover, understanding the dynamics of water distribution can help optimize harvesting time and improve processing efficiency. For example, grains harvested at optimal moisture levels exhibit better milling quality and reduced energy consumption during drying.

Conclusion

The study of grains of *Triticum aestivum* has shown that the ripening process is closely associated with significant changes in both the content and state of water. As the grain develops from the milk stage to full maturity, the total moisture content decreases steadily, reflecting the gradual completion of physiological and biochemical processes.

One of the key findings is the transformation of water from free to bound forms. In the early stages, free water predominates and ensures high metabolic activity, while in the later stages, bound water becomes dominant due to its association with accumulated macromolecules such as proteins and starch. This transition plays a crucial role in stabilizing the internal structure of the grain and preparing it for storage.

The research also confirmed that water distribution within the grain is heterogeneous. The embryo and outer layers retain relatively higher moisture compared to the endosperm, especially at later stages of ripening. This uneven distribution is related to the functional roles of different grain tissues and their biochemical composition.

Overall, the reduction of free water and the increase in bound water at full maturity significantly improve grain quality, enhance resistance to mechanical damage, and ensure better storage stability. These findings are important for determining optimal harvesting time, improving post-harvest handling, and developing efficient storage technologies.

Literature

1. Elmuradov, B., Saitkulov, F., Mirvaliev, Z., Ibragimov, A., Karimov, S., & Karimov, B. (2025, February). Synthesis of urea derivatives based on toluyl isocyanate. In AIP Conference Proceedings (Vol. 3268, No. 1). AIP Publishing.
2. Saitkulov, F., Zakhidov, Q., Khaydarov, G., Sabirova, D., Ergasheva, H., Mirvaliev, Z., & Usnatdinova, S. (2025, February). Methods for the synthesis of 2-phenylquinazolin-4-one and studying methylation reactions in different solvents. In AIP Conference Proceedings (Vol. 3268, No. 1). AIP Publishing.

3. Ashurova Z. B., Khaydarov G. Sh., Saitkulov F. E., Giyasov K. (2024). Determination of Certain Heavy Metals in Food Composition by Voltammetric Method. Austrian Journal of Technical and Natural Sciences 2024, No 3 – 4. https://doi.org/10.29013/AJT-24-11.12-47-51
4. Saitkulov F.E., Qayumova F. Synthesis of coordination compounds based on cobalt(ii) salts and quinazolin-4-ONE and the study of their biological activity // Universum: химия и биология : электрон. научн. журн. 2025. 2(128). URL: https://7universum.com/ru/nature/archive/item/19240
5. Akhmedova, N., Elmuradov, B., & Saitkulov, F. (2024). Optimal synthesis methods and biological activity study of 2-(4-nitrophenil) quinazolin-4-one. *Multidisciplinary Journal of Science and Technology*, *4*(12), 1192-1200.
6. Shoyimovich, K. G., Orinbaevna, B. G., & Ergashevich, S. F. (2024). Synthesis and study of biological activity of coordination compounds based on copper (ii) nitrate and quinazolin-4-one. *Austrian Journal of Technical & Natural Sciences*.
7. Shoyimovich, K. G., Ergashevich, S. F., & Kuchkar, G. (2024). Determination of certain heavy metals in food composition by voltammetric method. *Austrian Journal of Technical & Natural Sciences*.
8. Abduxakimovich, Z. F., Ergashevich, S. F., Jurayevich, E. B., & Xurramovich, A. R. (2024). Study of benzylation reactions of quinazolin-4-one in the presence of various solvents. *Austrian Journal of Technical and Natural Sciences*, 52.
9. Bekboyevich, O. O., Ergashevich, S. F., Zoxidovich, M. Z., & Orinaevna, B. G. (2024). Investigation of aromatic properties of xinazolin-4-one. *Austrian Journal of Technical & Natural Sciences*.
10. Juraevich, E. C., Ergashevich, S. F., Kuchkar, G., & Kilichovna, M. N. (2024). Convenient synthesis of 2-methylquinazolin-4-thione based on anthranyl acid. austrian journal of technical and natural sciences, 26.
11. Саиткулов, Ф. Э., Элмурадов, Б. Ж., & Гиясов, К. (2023). Алкилирования хиназолин-4-она «мягким» и «жестким» алкилирующими агентами. *Universum: химия и биология*, (1-2 (103)), 53-56.
12. Baymuratova, G., Nasimov, K., & Saitkulov, F. (2023). Synthesis of 6-benzylaminopurine and the study of biological active properties of cotton C-6424 plants. In E3S Web of Conferences (Vol. 389, p. 03032). EDP Sciences.
13. Saitkulov, F., Qilichyeva, N., Abdullayev, B., Anvarov, A., & Ergasheva, M. (2022). Titrimetric analysis of calcium cation in" megaton" variety of cabbage. *International Bulletin of Applied Science and Technology*, *2*(10), 134-135.

14. Саиткулов, Ф. Э., Гиясов, К., & Элмурадов, Б. Ж. (2022). Метилирование 2-метилхиназолин-4-она «мягкими» и «жесткими» метилирующими агентами. *Universum: химия и биология*, (11-2 (101)), 49-51.

15. Boymuratova, G. O., Saitkulov, F. E., Nasimov, K. M., & Tugalov, M. (2022). To Examine the Processes of Biochemical Action Of 6-Benzylaminopurine with Cobalt-II Nitrate Dihydrate on the “Morus Alba” Variety of Moraceae Plant. *Eurasian Journal of Physics, Chemistry and Mathematics*, *3*, 39-42.

16. Saitkulov, F., Begimqulov, I., O‘ralova, N., Gulimmatova, R., & Rahmonqulova, D. (2022). Biochemical effects of the coordination compound of cobalt-II nitrate quinazolin-4-one with 3-indolyl acetic acid in the “amber” plants grades phaseolus aureus. *Академические исследования в современной науке*, *1*(17), 263-267.

17. Saitkulov, F., Ibragimov, B. R., Allaqulova, M., Umarov, S., & Xolmatova, M. (2022). The role in the plant and the functions of nutrients. *Инновационные исследования в науке*, *1*(16), 29-31.

18. Saitkulov, F., Elmuradov, B., O’lmasova, K., & Alijonova, A. (2023). preparation of a mixed coordination compound cobalt-ii nitrate hexahydrate with quinazoline-4-one and 3-indolylacetic acid on “amber” plants of the phaseolus aureus variety. *Science and innovation in the education system*, *2*(1), 81-87.