

The work's outcomes systematize knowledge about artificial intelligence technologies that are currently on the market. These technologies have, in one way or another, shown themselves to be effective in solving issues related to agriculture and the agro-industrial complex, and over the next five to seven

years, there will be a significant push toward their dissemination. With the introduction of the technologies discussed in the article, their current development enables the economic entity to extract the dominant competitive advantages and the associated considerable economic effect.

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РЕЗЮМЕ. Мақоллада қишлоқ xo'jaligining noaniq ma'lumotlar bilan ishlashi uchun ko'plab istiqbollarni taqdim etadigan raqamli iqtisodiyot va tegishli texnologiyalarning paydo bo'lishi haqida takidlab o'tilgan. Asosan, maqsad qishloq xo'jaligi ishchilariga qishloq xo'jaligi sharoitlarida katta hajmdagi ma'lumotlarni taqdim etuvchi ilg'or texnologiyalardan foydalanish imkoniyatlari ko'rib chiqilgan.

РЕЗЮМЕ. В статье освещено появление цифровой экономики и связанных с ней технологий, которые открывают множество перспектив для работы с неопределенными данными в сельском хозяйстве. В основном были рассмотрены возможности использования передовых технологий, обеспечивающих большой объем информации в условиях сельского хозяйства целевым сельхозработникам.

SUMMARY. The article highlights the emergence of the digital economy and related technologies, which provide many perspectives for working with uncertain data in agriculture. Mainly, the possibilities of using advanced technologies that provide were considered a large amount of information in agricultural conditions to the target agricultural workers.

SENSORS FOR DETERMINING MICROCLIMATES IN FRUIT AND VEGETABLE STORAGE FACILITIES

F.N.Norqulova – magistr
Karshi state university

Tayanch so'zlar: mikroiklim sensorlari, meva va sabzavotlarnisaqlash, harorat monitoringi, namlik nazorati, IoT-texnologiyasi, atmosferani boshqariladigan saqlash, oziq-ovqat mahsulotlarini saqlash, energiya tejaydigan sensorlar, qishloq xo'jaligi innovatsiyasi, oziq-ovqat barqarorligi.

Ключевые слова: датчики микроклимата, хранение фруктов и овощей, мониторинг температуры, контроль влажности, технология IoT, хранение в контролируемой атмосфере, сохранение продуктов питания, энергоэффективные датчики, сельскохозяйственные инновации, продовольственная устойчивость.

Key words: microclimate sensors, fruit and vegetable storage, temperature monitoring, humidity control, IoT technology, controlled atmosphere storage, food preservation, energy-efficient sensors, agricultural innovation, food sustainability.

The storage of fruits and vegetables requires specific environmental conditions to maintain their freshness and quality. Microclimate control in storage warehouses is essential to ensure optimal temperature, humidity, and air quality. Advanced sensors play a crucial role in monitoring and managing these factors.

Sensors for determining microclimates in fruit and vegetable storage facilities are essential for maintaining quality and extending shelf life. These sensors measure temperature, humidity, carbon dioxide, and oxygen levels, directly affecting the preservation of produce. Temperature sensors ensure optimal cooling, while

humidity sensors prevent dehydration and fungal growth. Carbon dioxide and oxygen sensors help regulate controlled atmosphere storage, slowing respiration rates and extending freshness. Advanced sensors provide real-time data and enable automated adjustments for efficiency. IoT-enabled sensors allow remote monitoring and alerts for quick action when needed [1]. Energy-efficient and wireless sensors reduce costs and simplify installation. Regular calibration ensures accuracy and reliability. Integrated systems using sensor data improve decision-making and optimize storage conditions. Their versatility makes them suitable for various storage types,

contributing to reduced spoilage, economic savings, and better product quality. These technologies are indispensable for modern agriculture and food supply chains [2].

Sensors for determining microclimates in fruit and vegetable storage facilities play a crucial role in ensuring product quality and minimizing waste. They monitor key parameters such as temperature, humidity, carbon dioxide, and oxygen, all of which directly impact the preservation of produce. Temperature sensors maintain the optimal cooling environment, while humidity sensors prevent moisture imbalance that can lead to dehydration or fungal growth. Carbon dioxide and oxygen sensors regulate controlled atmosphere storage, slowing the respiration rates of fruits and vegetables to extend freshness. These sensors provide real-time data, enabling automated systems to adjust environmental conditions promptly and with precision [3].

IoT-enabled sensors allow facility managers to monitor conditions remotely, sending alerts when parameters deviate from the desired range. Wireless sensors are particularly advantageous as they simplify installation, reduce maintenance costs, and ensure flexibility in large-scale facilities. Energy-efficient designs further enhance their cost-effectiveness, making them ideal for long-term use. Regular calibration and maintenance are critical to ensuring sensor accuracy and reliability, preventing errors that could lead to product spoilage.

Integrated sensor systems also enable data analysis for better decision-making. Historical data on environmental conditions can be used to optimize storage strategies for various types of produce, improving overall operational efficiency. The adaptability of sensors to different storage types, such as cold storage, modified atmosphere storage, or traditional warehouses, demonstrates their versatility and value in the agricultural supply chain.

By reducing spoilage, maintaining product quality, and ensuring efficient resource use, microclimate sensors are transforming storage facilities into smarter, more sustainable operations. These technologies not only benefit producers and distributors but also ensure that consumers receive fresh, high-quality fruits and vegetables, representing a significant advancement in modern agriculture and food storage systems [4].

Sensors for determining microclimates in fruit and vegetable storage facilities are indispensable for preserving the quality, nutritional value, and marketability of produce. These sensors constantly monitor essential parameters like temperature, humidity, carbon dioxide, oxygen, and ethylene levels, all of which directly affect the longevity of stored fruits and vegetables. Temperature sensors ensure that the storage environment is cool enough to slow down metabolic processes but not so cold that it causes chilling injury. Humidity sensors maintain the right moisture balance, preventing dehydration, wilting, or mold formation [5].

Carbon dioxide and oxygen sensors are integral to controlled atmosphere storage, where altering gas concentrations reduces respiration rates and delays ripening and decay. Ethylene sensors, meanwhile, detect the presence of this natural ripening hormone, allowing for its removal to extend shelf life. Real-time data provided by these sensors is fed into automated systems that adjust environmental conditions to meet the specific needs of the stored produce [6].

Sensor Type	Function	Application
Temperature Sensor	Measures ambient temperature	Prevents freezing or overheating of produce
Humidity Sensor	Monitors moisture levels	Maintains optimal Humidity to avoid spoilage
CO2 Sensor	Detects carbon dioxide levels	Ensures proper ventilation
Ethylene Sensor	Measures ethylenegas	Controls ripening of fruits
Light Sensor	Monitors light exposure	Protects sensitive products from light damage

The integration of IoT technology has revolutionized storage monitoring. IoT-enabled sensors allow remote access to storage data, enabling managers to take immediate corrective action in case of deviations. Alerts and notifications sent via mobile or web applications ensure round-the-clock monitoring. Wireless sensors, which require minimal installation effort and reduce the need for extensive wiring, are particularly beneficial for large storage facilities [7].

Energy efficiency is another significant advantage of modern sensors. Low-power designs and rechargeable options make them suitable for long-term, sustainable operations. Advanced analytics and machine learning algorithms further enhance sensor functionality by predicting potential issues based on historical trends, allowing for proactive measures to safeguard produce.

Regular maintenance and calibration of sensors ensure that their readings remain accurate over time. Facilities that invest in proper sensor management enjoy reduced spoilage rates, lower operational costs, and a more efficient supply chain. The adaptability of sensors to different storage methods, including cold storage, frozen storage, and ambient storage, highlights their importance across various agricultural and industrial applications.

In conclusion, sensors for microclimate monitoring are more than just tools for preservation; they are a cornerstone of modern food storage technologies. They contribute to sustainability by reducing food waste, optimizing energy usage, and ensuring consistent product quality. As global demand for fresh produce continues to grow, these sensors will remain at the forefront of innovation in agricultural and post-harvest technologies, benefiting farmers, distributors, and consumers alike.

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REZYUME. Ushbu maqola harorat, namlik, karbonat anhidrid, kislorod va etilen darajalari kabi muhim atrof-muhit parametrlarini kuzatish va tartibga solishda ilg'or sensorlarning rolini o'rganadi. IoT texnologiyasini integratsiyalashgan holda, ushbu sensorlar real vaqt rejimida ma'lumotlarni yig'ish, masofadan turib monitoring qilish va avtomatlashtirilgan boshqaruv tizimlarini saqlangan mahsulot sifati va uzoq umr ko'rishini ta'minlaydi.

РЕЗЮМЕ. В этой статье исследуется роль современных датчиков в мониторинге и регулировании основных параметров окружающей среды, таких как температура, влажность, уровни углекислого газа, кислорода и этилена. Благодаря интеграции технологии Интернета вещей эти датчики обеспечивают сбор данных в реальном времени, удаленный мониторинг и автоматизированные системы управления для обеспечения качества и долговечности хранимой продукции.

SUMMARY. This article explores the role of advanced sensors in monitoring and regulating essential environmental parameters such as temperature, humidity, carbon dioxide, oxygen, and ethylene levels. By integrating IoT technology, these sensors enable real-time data collection, remote monitoring, and automated control systems to ensure the quality and longevity of stored produce.

BERNULLI SONLARINING BA'ZI TADBIQLARI

B.B.Prenov – fizika-matematika fanlari doktori (DSc)

Ajiniyoz nomidagi Nukus davlat pedagogika instituti

J.Sh.Abdullayev – fizika-matematika fanlari bo'yicha falsafa doktori, dotsent
Urganch davlat universiteti

I.T.Xaldibayeva – dotsent (v.b.)

Toshkent davlat texnika universiteti

Tayanch so'zlar: Bernulli sonlari, darajali qatorlar, yaqinlashish radiusi, chekli yig'indi.

Ключевые слова: числа Бернулли, степенные ряды, радиус сходимости, конечная сумма.

Key words: Bernoulli numbers, power series, radius of convergence, terminating sum.

Bernulli sonlari matematikada juda muhim va qiziqarli konsepsiyalardan biridir. Ushbu sonlar asosan kombinatorika, ehtimollar nazariyasi, differensial tenglamalar va analiz kabi sohalarida keng qo'llaniladi. Bernulli sonlari, shuningdek, turli xil matematik qatorlarni hisoblashda, masalan, trigonometrik funksiyalarni yoyishda yoki zeta funksiyalarini o'rganishda muhim rol o'ynaydi. Bu sonlar Jakob Bernulli sharafiga nomlangan bo'lib, u ularni birinchi marta o'rganib, ularning xususiyatlarini aniqlagan.

Bernulli sonlari butun sonlar va ratsional sonlar bilan chambarchas bog'liq bo'lib, ularning o'ziga xos rekursiv formulalari va generator funksiyalari orqali aniqlanadi. Ular yordamida maxsus qatorlarni soddalashtirish, differensial va integral tenglamalarni yechishda aniq formulalar hosil qilish, shuningdek, sonlar nazariyasidagi qiyin muammolarni osonlashtirish mumkin. Aynan shuning uchun Bernulli sonlari nafaqat nazariy matematika, balki muhandislik, fizika va hatto moliyaviy hisob-kitoblarda ham muhim rol o'ynaydi.

Kompleks sonlar tabiiy fanlarning turli sohalarida keng qo'llaniladi. Ular yordamida mexanika va fizikaning ko'pgina masalalari o'z yechimini topgan.

Shuningdek, bu sonlar algebraik va geometrik tathbiqlarga ega. Ushbu maqolada kompleks o'zgaruvchili darajali qatorlar nisbati yordamida natural sonlar qatorining natural darajali yig'indilarini hisoblash uchun umumiy formula keltirilib chiqarilgan.

Dastlab ikkita darajali qator nisbatini darajali qatorga yoyishni ko'rib chiqamiz. Aytaylik, bizga ikkita

$$f_1(z) = a_0 + a_1z + \dots + a_nz^n + \dots \quad (1)$$

va

$$f_2(z) = b_0 + b_1z + \dots + b_nz^n + \dots \quad (2)$$

darajali qatorlar berilgan bo'lib, bu darajali qatorning yaqinlashish radiuslari mos ravishda musbat r va ρ bo'lsin. Bunda (2) qator uchun $f_2(0) = b_0 \neq 0$ σ orqali r va ρ larnig kichigini belgilaymiz: $\sigma = \min(r, \rho)$. U holda $|z| < \sigma$ doirada ikkala qator ham yaqinlashadi. Agar bu doirada $f_2(z)$ funksiyaning nollari bo'lsa, radiusi σ dan kichik bo'lgan shunday doira olamizki, yangi doirada $f_2(z)$ nolga aylanmaydi ($b_0 \neq 0$). Bu doiraning radiusi R bo'lsin. $|z| < R$ doira ichida