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Integration of Neural Network Technologies into the Methodology of Teaching Sensory Analysis for Food Technology Students

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Abstract. *The article examines the implementation of neural network technologies in the educational process for training food technology specialists, with the aim of modeling sensory evaluations, optimizing practical classes, and developing students' critical thinking and professional skills. The purpose of the article is to investigate and substantiate the opportunities for integrating neural network technologies into the methodology of teaching sensory analysis for the training of food technology specialists, as well as to identify effective approaches to the use of artificial intelligence to improve the quality of the educational process and to build the professional competencies of future food industry professionals.*

Methods. *A comprehensive methodological approach was applied that integrates pedagogical, experimental, and information technology research methods. The pedagogical component includes analysis of curricula, development of didactic materials, and evaluation of teaching effectiveness using intelligent systems. The experimental component was implemented through the modeling of controlled experiments to assess the impact of neural networks on the development of students'*

sensory competencies. The information technology component supports the use of machine learning and deep learning algorithms for processing sensory data and creating personalized learning platforms. This approach makes it possible to assess the potential of artificial intelligence in education and to formulate recommendations for the optimal implementation of relevant tools.

Results. *The use of neural network technologies in the educational process was found to enhance the effectiveness of mastering complex sensory characteristics of food products, optimize the development of professional skills, and enable the modeling of individualized learning trajectories. Artificial intelligence algorithms enable automated analysis of students' responses to different sensory stimuli, prediction of assessment accuracy, and real-time adjustment of methodological approaches. This increases the interactivity of classes, stimulates active cognitive engagement, and supports a deeper understanding of the mechanisms underlying the perception of taste, aroma, and texture attributes of products.*

Conclusions. *It is substantiated that the introduction of neural network technologies into the teaching of sensory analysis significantly improves the effectiveness of training students in the Food Technology specialty. This approach promotes a deeper understanding of the relationship between the physicochemical properties of a product and its organoleptic characteristics, which is essential for the professional preparation of future technologists. The application of artificial neural networks makes it possible to model and predict the sensory properties of products based on a comprehensive analysis of large datasets, providing students with practical skills in working with digital tools and forming competencies required for the implementation of innovative technologies in the food industry. The use of interactive educational models incorporating elements of neural network analysis increases student motivation, stimulates cognitive activity, and supports the development of analytical thinking needed for evidence-based technological decision-making in food production. Effective implementation of neural network technologies requires a systematic approach that includes the development of appropriate methodological*

support, adaptation of software, and advanced training for instructors. Promising directions for further research include optimizing neural network models for predicting the sensory characteristics of products and developing adaptive learning platforms to individualize the educational process and improve the quality of training for food technology specialists.

Keywords: *artificial intelligence, deep learning, education, professional training, sensory evaluation, food industry, innovative methods, practical training, technological processes, analytical skills.*

Інтеграція нейромережевих технологій у методику викладання сенсорного аналізу для технологів харчових продуктів

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Анотація: У статті досліджено впровадження нейромережевих технологій у навчальний процес підготовки технологів харчових продуктів для моделювання сенсорних оцінок, оптимізації практичних занять і формування у студентів критичного мислення та професійних навичок.

Мета статті – дослідження та обґрунтування можливостей інтеграції нейромережевих технологій у методику викладання сенсорного аналізу для підготовки технологів харчових продуктів, а також визначення ефективних підходів до використання штучного інтелекту з метою підвищення якості навчального процесу та формування професійних компетентностей майбутніх фахівців харчової промисловості.

Методи. Застосовано комплексний методичний підхід, що поєднує педагогічні, експериментальні та інформаційно-технологічні методи дослідження. Педагогічний складник охоплює аналіз навчальних програм, розроблення дидактичних матеріалів і оцінювання ефективності викладання за допомогою інтелектуальних систем. Експериментальний аспект реалізовано через моделювання контрольованих дослідів для оцінювання впливу нейромереж на розвиток сенсорних компетентностей студентів. Інформаційно-технологічний складник забезпечує застосування алгоритмів машинного та глибинного навчання для опрацювання сенсорних даних і створення персоналізованих навчальних платформ. Такий підхід дозволяє оцінити потенціал штучного інтелекту в освіті та виробити рекомендації щодо оптимального впровадження відповідних інструментів.

Результати. Встановлено, що застосування нейромережевих технологій у навчальному процесі сприяє підвищенню ефективності засвоєння складних сенсорних характеристик харчових продуктів, оптимізує формування професійних навичок і дозволяє моделювати індивідуальні траєкторії навчання. Алгоритми штучного інтелекту уможливлюють автоматичний аналіз реакцій студентів на різні сенсорні стимули, прогнозування точності оцінок та коригування методичних підходів у реальному часі. Це підвищує інтерактивність занять, стимулює активну когнітивну діяльність і формує глибше розуміння механізмів сприйняття смакових, ароматичних і текстурних характеристик продуктів.

Висновки. Обґрунтовано, що впровадження нейромережевих технологій у процес викладання сенсорного аналізу суттєво підвищує ефективність підготовки здобувачів освіти спеціальності «Технології харчових продуктів». Такий підхід сприяє глибшому розумінню взаємозв’язку між фізико-хімічними властивостями продукту та його органолептичними характеристиками, що є визначальним для професійної підготовки майбутніх технологів. Застосування штучних нейронних мереж дозволяє моделювати та прогнозувати сенсорні

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властивості продуктів на основі комплексного аналізу великих масивів даних, що надає студентам практичні навички роботи з цифровими інструментами та формує компетентності, необхідні для впровадження інноваційних технологій у харчовій промисловості. Використання інтерактивних освітніх моделей з елементами нейромережевого аналізу підвищує мотивацію студентів, стимулює їхню когнітивну активність і сприяє розвитку аналітичного мислення, необхідного для прийняття обґрунтованих технологічних рішень у виробництві харчових продуктів. Ефективне впровадження нейромережевих технологій потребує системного підходу, що передбачає розроблення відповідного методичного забезпечення, адаптацію програмного забезпечення та підвищення кваліфікації викладачів.

Перспективними напрямами подальших досліджень визначено оптимізацію моделей нейромережевого прогнозування сенсорних характеристик продуктів, а також розроблення адаптивних навчальних платформ для індивідуалізації навчального процесу і підвищення якості підготовки технологів харчових продуктів.

Ключові слова: штучний інтелект, глибинне навчання, освіта, професійна підготовка, сенсорне оцінювання, харчова промисловість, інноваційні методики, практичне навчання, технологічні процеси, аналітичні навички.

Introduction. The contemporary food industry operates under intense market competition, ongoing technological transformation, and steadily increasing expectations for product safety and quality. In this context, educating highly qualified food technologists is essential, especially professionals able to systematically monitor and manage the quality of raw materials, processing operations, and finished products while ensuring compliance with regulatory and standard requirements, including ISO, HACCP, and Codex Alimentarius. A central instrument of food quality assurance is sensory analysis, understood as a systematic, scientifically grounded approach to evaluating organoleptic product characteristics, including taste, aroma, texture, and color.

Sensory analysis generates both quantitative and qualitative evidence that supports quality control and product development. In quality assurance practice, it serves as a mechanism for verifying the alignment of sensory profiles with predefined specifications and consumer expectations. In innovation-oriented workflows, it facilitates the design and refinement of products with predictable sensory attributes, thereby reducing uncertainty during formulation and process optimization. Because sensory perception is influenced by physiological variability and contextual factors, dependable sensory evaluation requires methodological rigor, including standardized procedures, controlled conditions, and appropriately trained assessors.

Mastery of sensory analysis methodology depends on integrating conceptual understanding with practical competence. This integration is commonly achieved through laboratory-based seminars and structured tasting sessions, supported by both group and individual practical training. To enhance objectivity and reproducibility, instruction should incorporate standardized sensory panels and validated evaluation protocols that reduce bias and strengthen the consistency of judgments across assessors and sessions. Such a pedagogically grounded approach equips students with the methodological discipline required for professional sensory work and prepares them to apply sensory evidence to decision-making across food technology contexts.

At the same time, contemporary food technology education faces persistent structural and methodological constraints. These constraints include limited laboratory infrastructure and equipment, the inherent subjectivity of sensory evaluation, variability in students' baseline preparation and prior experience, and the need to individualize instruction by accounting for each student's cognitive and sensory characteristics. Collectively, these factors underscore the need for innovative educational technologies that can strengthen the effectiveness of sensory competence development while improving the reliability and accuracy of organoleptic assessment.

A particularly promising direction is the integration of neural network technologies and broader artificial intelligence approaches into the pedagogical methodology used to train food technologists. Machine learning models and AI algorithms can support automated analysis of sensory data, computational modeling of taste and aroma profiles, prediction of consumer responses to novel products, and the development of adaptive learning platforms that calibrate instructional pathways to students' individual cognitive and sensory profiles. Although prior studies have examined neural network applications in the food industry and AI-enabled educational technologies, comprehensive implementation of these tools within the professional training system for sensory analysis remains insufficiently developed and warrants systematic scientific justification.

Therefore, this study is relevant because it addresses the need to develop scientifically grounded methodological approaches for integrating neural network technologies into the educational process used to train food technologists. Such integration is expected to improve the effectiveness of practical skill development, enhance the objectivity and reproducibility of organoleptic assessment, increase the adaptability of instruction to learners' needs, and align training outcomes with contemporary technological and market demands in the food industry.

Literature Review. In contemporary scientific discourse, there is growing interest in the application of artificial intelligence technologies, particularly neural network systems, in both education and food technology. This interest is driven by the ongoing digital transformation of the educational environment and the development of advanced tools for analyzing the sensory characteristics of food products.

Researcher T. Tardaskina emphasizes innovative methodological approaches to the digital transformation of higher education and explores its impact on optimizing educational quality. These advancements ensure increased accessibility, flexibility, and personalization of learning, while also integrating digital communication and collaboration tools to foster creativity and innovative thinking among educational stakeholders. It has been established that a key technological trend is the

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implementation of artificial intelligence systems, which enable a personalized educational experience, enhance the effectiveness of pedagogical practices and professional training, and provide a solid foundation for the continued modernization of the educational ecosystem [1].

Within this context, the studies conducted by S. Lytvynova, Yu. Nosenko, and A. Sukhikh have highlighted the unique characteristics of integrating augmented and virtual reality (AR/VR) technologies into the blended learning paradigm, particularly in the midst of the digital transformation of education. Their research specifically emphasizes the adaptive integration of immersive tools in alignment with the principles of pedagogical appropriateness, didactic effectiveness, and the personalization of the learning environment. The findings of their work include the conceptual development and design of the electronic resource "Catalogue of Immersive Services," which serves as a structured platform for navigating AR/VR tools. This platform is equipped with advanced filtering and analytical features to support teachers in making informed decisions regarding instructional tools [2].

The T. T. Tu et al. substantiate the potential of intelligent computer systems as «software sensors» capable of predictive modeling and evaluation of food product parameters, in particular with the use of fuzzy neural networks (FNN), which are effective for processing uncertain data and integrating expert knowledge into formalized technological models. The study analyzes the possibilities of using these artificial intelligence tools for sensory analysis of fresh milk in order to improve metrological accuracy, objectivity of quality control, and optimization of evaluation procedures [3].

Ray S. emphasizes that the sensory experience of food consumption is a critical determinant of consumer satisfaction and the commercial success of food products. Sensory analysis, as an interdisciplinary field, necessitates the integration of methods for evaluating, optimizing, and interpreting sensory characteristics. Sensory attributes are assessed using both subjective (organoleptic, hedonic) and objective

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(discriminatory, instrumental) methods. The combination of these approaches provides a comprehensive description of the qualitative properties of food products [4].

Morshed M. S. et al. conducted research on automated and accurate food recognition and quality assessment, focusing on the application of deep learning techniques in the agricultural sector. They proposed the use of dense convolutional neural networks (DenseNets) to effectively propagate features, address the vanishing gradient problem, and enhance fruit classification performance [5].

In their study, Wei et al. proposed a comprehensive methodology for evaluating the sensory properties of dairy products from the Kazakh ethnic group in Xinjiang. This approach combined fuzzy analytical hierarchy, an optimal consistency matrix, and cluster analysis based on a self-organizing neural network (SOM). The results revealed taste differences between samples from Altai and Ili, confirming the system's suitability for both qualitative and quantitative analysis of geographically diverse dairy products [6].

Wei, Z. et al. explored the integration of artificial neural networks into the teaching methodology of sensory analysis. This integration facilitates the modeling of sensory perception processes for evaluating the organoleptic properties of products, enhancing students' cognitive engagement, analytical thinking, and professional competence. The use of digital platforms and machine learning algorithms in laboratory workshops creates an adaptive learning environment with instant feedback and standardized product evaluations, minimizing the subjective influence of individual perception characteristics [6].

Xia X. et al. emphasized the role of taste as a critical sensory mechanism for evaluating both nutritious and potentially toxic components in food products. They noted that traditional sensory evaluation methods, such as expert evaluation and the electronic tongue, are limited by subjectivity, low repeatability, and insufficient adaptability. The study proposed a method for decoding objective taste perception using taste EEG analysis, combined with the temporal-spatial data refinement (TSRDA) method. Additionally, the research integrated a multi-channel attention

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module into a convolutional neural network to extract the most informative features, improving the reliability and accuracy of taste evaluation [7].

A study by Ling J. and R. Heldman D. emphasizes that the sensory characteristics of taste play a crucial role in determining consumers’ food preferences and purchasing behavior, which is a critical area of research in food science. Traditional taste assessment methods, including sensory analysis and instrumental approaches, have limitations when processing large datasets and forming integrated conclusions. The integration of advanced neural network models and machine learning algorithms offers new opportunities to enhance the accuracy of forecasting and optimize sensory analysis techniques, effectively overcoming the traditional methodological barriers [8].

Sun X. et al. investigate the integration of artificial neural networks into the teaching methodology of sensory analysis, which enables the modeling of sensory perception mechanisms related to the organoleptic characteristics of food products. This approach contributes to enhancing students' cognitive activity, fostering the development of analytical thinking, and cultivating professional competence. The use of digital platforms and machine learning algorithms in laboratory workshops creates an adaptive learning environment that provides rapid feedback and standardized product evaluations, minimizing the influence of subjective sensory perception characteristics [9].

Thus, scientific research highlights the significance of incorporating neural network technologies into the methodology of teaching sensory analysis for food technologists as a means to improve the effectiveness of professional competence development. The application of artificial neural networks facilitates the modeling of complex sensory processes, enables the analysis of multidimensional data on the taste and aroma characteristics of food products, and contributes to the enhancement of students' analytical and critical thinking skills by simulating practical experiments within a virtual environment.

Identification of Unresolved Aspects of the General Problem. An analysis of current scientific research in the field of sensory analysis of food products and the application of neural network technologies in pedagogical practice reveals that previous studies have primarily focused on two key areas: enhancing sensory evaluation methodologies and incorporating digital technologies into the educational process. Specifically, recent empirical and theoretical studies highlight the high effectiveness of electronic learning platforms, virtual simulations, software for modeling sensory characteristics of food products, and interactive learning environments that allow for real-time monitoring and assessment of students' learning activities.

However, the integration of neural network algorithms into the sensory analysis learning process remains insufficiently explored, indicating a theoretical and methodological gap in this area. A particularly critical gap exists in the availability of systematic and adaptive approaches for designing training models that accommodate the individual cognitive, sensory, and psychophysiological profiles of food technology students. The current literature offers limited empirical evidence regarding the impact of neural network technologies on the effectiveness of practical skill acquisition in assessing the organoleptic properties of food products, as well as on the development of essential professional competencies such as sensory acuity, critical thinking, and evidence-based decision-making in production environments.

Furthermore, there is a lack of integrated methodological approaches that combine traditional sensory analysis methods with the capabilities of neural network models for predicting and modeling complex sensory parameters of food products. The challenge of optimizing the educational process by personalizing learning content and incorporating automated feedback mechanisms remains unresolved. This issue is crucial for improving the training quality of highly qualified specialists in the food industry and developing their professional competencies in alignment with modern educational standards.

In conclusion, scientific literature reveals a significant gap in the development of comprehensive pedagogical methods that integrate neural network technologies into the teaching of sensory analysis of food products. Such methods must ensure adaptability, methodological soundness, and effectiveness in forming the professional competencies of future technologists. Promising areas for further research include the creation of hybrid training models that combine practical sensory experiments with digital modeling, as well as the exploration of cognitive and neurophysiological mechanisms involved in sensory information assimilation within the context of artificial intelligence.

Formulation of the Article's Objectives. The aim of this article is to explore and substantiate the potential for integrating neural network technologies into the methodology of teaching sensory analysis for food technologists. It seeks to identify effective approaches for utilizing artificial intelligence to enhance the quality of the educational process and the development of professional competencies in future specialists within the food industry.

The objectives of the article are as follows:

1. To analyze the current application of neural network technologies in the educational process and evaluate their potential to improve the effectiveness of training in the food industry.
2. To examine the methodological aspects of teaching sensory analysis and identify key areas that can be enhanced through the application of artificial intelligence.
3. To develop conceptual approaches for integrating neural network technologies into sensory analysis teaching practices aimed at training food technologists.
4. To identify effective strategies for using intelligent systems to foster the development of professional competencies in future food industry specialists.

Results. The ongoing development of the food industry and food production technologies has led to increased demands for the professional competence of specialists, particularly in the field of sensory analysis. Sensory evaluation of food

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quality is a strategically essential tool for controlling technological processes, managing recipes, and ensuring product compliance with regulatory quality standards (e.g., ISO 5492, ISO 8586). This process involves a comprehensive study of the organoleptic characteristics of a product, such as taste, smell, texture, appearance, and aftertaste, with the goal of objectively evaluating these characteristics and predicting consumer perception. Sensory expertise, as an integral part of the quality control system, facilitates multi-level analysis of recipe components, technological parameters of production, and their interaction with the organoleptic indicators of the final product.

In this context, the educational process within food technology is increasingly incorporating innovative methods, with neural network technologies and artificial intelligence (AI) playing a pivotal role. The use of neural network models enables the simulation of sensory perception, the prediction of consumers' organoleptic reactions, the optimization of recipe formulations, and the enhancement of quality control accuracy throughout all stages of production. Additionally, these technologies contribute to the development of students' critical and analytical thinking, facilitate the interpretation of sensory data, and support informed decision-making in real-world production environments [11].

The relevance of this study is rooted in the need for a scientific and methodological foundation for integrating neural network technologies into the educational process of sensory analysis for food products. This integration improves the effectiveness of training future technologists and specialists in the food industry, ensuring the development of competencies in predicting the organoleptic properties of products, performing quality control, and making optimal technological decisions. Against this backdrop, the objective of this section is to systematize current approaches to integrating neural network models into the educational process, analyze their effectiveness, and identify the practical applications of these technologies for training highly qualified specialists in the field of food technology.

The modern education system is experiencing a dynamic integration of digital technologies, with neural network technologies and artificial intelligence playing a

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central role as tools for educational innovation and the intellectualization of the learning process. This transformation is driven by the need to adapt teaching practices to the challenges of the 21st century, improve the cognitive and professional competence of specialists, and create an environment that supports individualized, adaptive, and differentiated learning. This shift is particularly relevant in fields that blend theoretical foundations with practical competencies, such as the food industry and the sensory analysis of food products [12].

Neural network technologies are increasingly utilized in modern education at various levels, ranging from automated knowledge assessment and adaptive testing systems to intelligent learning platforms that facilitate cognitive analytics and decision-making in learning. The use of neural networks enables the development of educational systems capable of effectively processing large volumes of data (big data) related to students' learning activities. These systems identify patterns in learning behavior and predict potential cognitive and practical challenges students may encounter while mastering the material. This capability allows educators to quickly adjust learning pathways, customize course content, implement differentiated instructional strategies, and enhance the overall effectiveness of the educational process through evidence-based analytics [13].

Within the context of the food industry and the professional preparation of food technologists, neural network-based solutions play a crucial role. First, they are capable of modeling complex sensory processes involved in product evaluation, automating the analysis of organoleptic characteristics such as taste, aroma, texture, color, and overall product quality. This capability is particularly beneficial for distance or blended learning environments, where access to laboratory equipment is limited, and students need to develop practical skills in food evaluation [14].

Second, neural network systems offer a high degree of personalization in learning. Through machine learning algorithms and the adaptive modeling of students' cognitive profiles, these platforms create individualized learning paths that consider prior experience, the pace of knowledge acquisition, and the nature of learning errors.

This personalization helps increase motivation, fosters the development of metacognitive skills, enhances critical thinking, and deepens students' understanding of technological processes in food production.

The integration of neural network technologies also offers the potential to create virtual and mixed laboratories within educational programs. Virtual simulations enable the modeling of real production scenarios, allowing students to conduct experiments on recipe development, assess the quality of raw materials and final products, and analyze the resulting data using artificial intelligence algorithms and predictive analytics methods. This fosters the deep development of practical competencies and brings the learning experience closer to real-world production conditions [15].

Despite the numerous advantages, the introduction of neural network technologies into the educational process presents several challenges. These include insufficient digital literacy among instructors, limited resources for creating and maintaining intelligent educational platforms, and ethical and legal concerns related to the processing of students' personal data. Addressing these challenges requires a comprehensive approach, which includes modernizing educational infrastructure, retraining educators, establishing regulatory mechanisms, and developing policies for digital security.

Thus, neural network technologies hold significant potential for enhancing the effectiveness of training in the food industry. They contribute to optimizing the educational process, improving the quality of knowledge acquisition and practical skill development, and creating conditions for personalized, adaptive, and interactive training for future food industry technologists. The effective integration of these technologies could become a strategic factor in increasing the competitiveness of educational programs in food technology at both the national and international levels. Research into the methodological aspects of teaching sensory analysis in the training of food industry technologists involves a systematic and comprehensive examination of didactic paradigms, organizational and pedagogical forms of educational interaction, and the instrumental and methodological support for the educational process. Within the context of a competency-oriented educational model, it is crucial to assess the effectiveness of teaching strategies designed to develop students' professionally significant cognitive, operational-technological, and reflective-analytical competencies. This evaluation includes analyzing the educational design of the discipline, optimizing the content and methodology of laboratory classes, and incorporating innovative pedagogical technologies that facilitate the integration of theoretical knowledge with practical sensory expertise (Table 1).

Table 1

Structure of Sensory Analysis

Component	Content
Scientific and Practical Essence	Sensory analysis as an interdisciplinary field integrating food technology, the psychophysiology of perception, cognitive psychology, metrology, and statistics.
Methods for Developing Sensitivity	The use of specialized approaches to develop sensory sensitivity and perceptual differentiation of stimuli.
Educational Priorities	Development of sensory memory, formation of descriptive evaluation tools, calibration of tasters, and standardization of experimental conditions.
Organoleptic Protocols	The use of standardized sensory testing procedures.
Assessment Scales	Application of intensity scales: linear, categorical, and hedonic.
Descriptor Profiles	Development of systems for describing the sensory characteristics of products.
Discriminatory Methods	Use of triangular, paired, and rank tests.
Statistical Procedures	Application of variance analysis, factor modeling, and clustering of results.

Source: compiled by the author based on [10; 16; 17]

Traditionally, training in sensory analysis has relied on a laboratory-practical form of educational activity, where students empirically master tasting evaluation methods and interpret results. However, classical didactic approaches often fail to

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provide sufficient individualization of the educational trajectory, operational formative assessment, and interactive feedback. As a result, these limitations hinder the development of metacognitive skills and adaptive self-regulation in students' educational activities.

In this context, it is essential to identify key aspects of teaching methods that can be optimized through the integration of digital technologies and artificial intelligence tools. These aspects include the algorithmic personalization of educational trajectories based on learning analytics, automated analysis of sensory testing results using machine learning techniques, modeling sensory profiles of food products through neural network forecasting, and the use of intelligent decision support systems to interpret empirical data. The application of deep learning, big data processing, and predictive analytics technologies enhances the validity of assessments, improves the accuracy of sensory characteristic classification, and increases the objectivity of expert conclusions [17, p. 118].

The integration of digital intelligent systems into the educational process facilitates the transformation of the learning environment, enhancing its adaptability, interactivity, and evidence-based orientation. This transformation supports the development of analytical and synthetic thinking in future specialists, fosters professional reflection, cultivates data processing skills, and strengthens interdisciplinary connections between the technological and informational components of training.

Thus, research into the methodological foundations of teaching sensory analysis, along with identifying areas for improvement through the use of artificial intelligence technologies, forms the scientific and theoretical foundation for modernizing the professional training of food technologists. This approach contributes to enhancing the pedagogical effectiveness of the educational process, expanding the opportunities for experimental and research-based learning, ensuring the integration of digital transformation principles in education, and aligning the content of training with the

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current challenges of the food technology industry and the evolution of an intellectualized production environment.

Current trends in the digital transformation of professional education, driven by the rapid development of information and communication technologies, artificial intelligence, and big data analytics, underscore the need to revise traditional methodological and didactic principles in teaching technology-related disciplines, particularly in the sensory analysis of food products. In light of the increasing complexity of organoleptic evaluation procedures, the multifaceted nature of product quality attributes, and the growing volume of experimental data, there is a pressing need to implement intelligent information-processing tools that can improve the validity, reliability, and reproducibility of assessment outcomes. In this context, the integration of neural network technologies represents a promising avenue for modernizing the educational process. These technologies provide cognitive support for learning activities, automate analytical procedures, and broaden students' research opportunities [17].

The development of conceptual approaches to the integration of artificial neural networks involves creating a methodologically sound pedagogical ecosystem for the interaction between digital intelligent tools and didactic practices aimed at developing the professional competencies of future food technologists. This ecosystem should incorporate principles such as the interoperability of educational platforms, adaptability of the learning environment, interactivity of communication processes, and cognitive ergonomics of the digital interface. It must ensure synergy between algorithmic data processing procedures and the pedagogical goals of training specialists.

The conceptual framework for integrating neural network technologies should be grounded in the convergence of competency-based, systemic, activity-based, and technology-based approaches, each serving as complementary methodological strategies. Within the competency paradigm, the application of machine learning algorithms and deep neural networks is aimed at fostering metacognitive skills,

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analytical thinking, the ability to statistically interpret sensory data, digital literacy, and proficiency in interacting with intelligent product quality prediction systems. The systematic approach ensures the integrative consistency of digital tools with educational objectives, the structure of educational content, criteria for assessing learning outcomes, and feedback mechanisms, thereby forming a cohesive didactic architecture for the educational process [18].

The activity-based approach emphasizes student engagement in practice-oriented research activities, including experimental modeling of sensory characteristics of products, working with datasets, adjusting neural network model parameters, and analyzing the results of their operation. The technological approach, in turn, focuses on the algorithmization of the implementation process for digital solutions—ranging from pedagogical design and tool prototyping to testing, validation, and monitoring of effectiveness in the educational environment. This approach involves the use of pedagogical diagnostics, learning analytics, and criteria for evaluating the effectiveness of digital innovations.

An important conceptual foundation of this study is the use of neural network technologies as a tool for cognitive visualization and interpretation of multidimensional sensory data. The application of deep learning algorithms, particularly convolutional and recurrent neural networks, in analyzing the taste, aroma, and texture characteristics of food products enables the creation of interactive educational environments with advanced simulation modeling. In such environments, students can conduct comparative analyses of tasting profiles, construct sensory maps, predict consumer properties of products, and identify latent patterns within experimental data. This approach fosters research autonomy, the development of critical thinking, and enhances objectivity in educational assessments through the use of algorithmic expertise [18].

Conceptual frameworks also advocate for the multi-level integration of neural network tools throughout the educational process—from the theoretical and methodological understanding of sensory analysis principles to the completion of

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laboratory, practical, and project-based research tasks. During the theoretical training phase, intelligent systems can provide adaptive personalization of educational content, develop individual learning trajectories, and automate the monitoring of academic progress. In practical activities, these systems are used to process sensory testing results, classify samples, build regression and predictive models, and optimize technological decision-making processes. This integration contributes to the transformation of the educational paradigm from a reproductive-instructional approach to a research-analytical mode of learning.

Developing conceptual approaches for integrating neural network technologies into sensory analysis teaching practices is essential for modernizing food technologist training within a digital educational environment. Implementing these approaches will enhance educational outcomes, foster the development of digital and research competencies, promote algorithmic thinking, and prepare future specialists to effectively utilize intellectual technologies in their professional activities. This aligns with the demands of the innovative economy and Industry 4.0 [19].

Identifying effective mechanisms for integrating intelligent systems into the development of professional competencies for future food industry specialists is a central task in modernizing industry-specific education amidst the digital transformation of society and the advancement of Industry 4.0. The relevance of this issue stems from the shift in education systems toward a competency-oriented paradigm, which incorporates digital technologies, artificial intelligence, and cognitive information environments into professional training frameworks. The integration of neural network technologies into the methodology of teaching sensory analysis creates the foundation for improving student training quality by implementing the adaptive, analytical, prognostic, diagnostic, and optimization functions of intelligent algorithms. This transformation shifts the educational process from a reproductive knowledge acquisition model to a cognitive-analytical framework for constructing professional experience.

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One of the most effective strategies is the use of intelligent systems as tools for digital modeling of sensory processes. The application of machine learning algorithms, deep learning methods, and convolutional and recurrent neural networks enables the formation of digital representations of organoleptic evaluations of food products that replicate the parameters of real production environments. Such virtualized environments facilitate the development of operational and critical thinking, help students interpret sensory indicators using multiple parameters, and support the acquisition of competencies necessary for making technological decisions based on the analysis of both structured and unstructured data. Additionally, simulation models foster professional reflection and the ability to predict changes in product quality resulting from variations in technological parameters [20].

An important component of digital didactics is the introduction of adaptive educational platforms based on Intelligent Tutoring Systems (ITS). These systems facilitate personalized educational trajectories by using educational analytics algorithms, automated profiling of learners' cognitive styles, and dynamic adjustments to educational content. Such platforms are grounded in the concepts of learning analytics, data-driven education, and predictive modeling, which enhance the effectiveness of learning and help develop metacognitive skills. As a result, students acquire professionally relevant competencies, including the ability to self-assess, critically analyze sensory data, self-regulate cognitive activity, and make reflective, informed decisions [21].

The use of intelligent data analysis systems, such as data mining and knowledge discovery, is particularly valuable when working with the results of laboratory research in sensory quality control of food products. The integration of software tools for statistical data processing, including methods like multidimensional analysis, clustering, regression modeling, and neural network forecasting, enables students to master the tools required for the quantitative interpretation of tasting test results. This integration aids in identifying latent patterns between raw material properties, technological process parameters, and final product characteristics, while also fostering

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an evidence-based approach to technological decision-making. In this way, theoretical knowledge is effectively integrated with practical skills in data analysis and professional forecasting.

Another important area is the use of intelligent virtual assistants, expert systems, and simulation-based educational environments that provide cognitive support for learning activities. These digital tools offer instant access to industry knowledge bases, automated explanations of complex technological operations, and real-time decision-making support. Their use fosters the development of information and digital literacy, algorithmic thinking, and the ability to operate in a digitalized production environment, where automated quality control and product parameter monitoring systems are becoming key components of the technological infrastructure.

Thus, the effectiveness of using intelligent systems in the training of food technologists is determined by their ability to ensure the synergistic integration of theoretical and methodological knowledge, practical professional skills, and analytical abilities within a unified digital educational environment. The implementation of these systems in teaching sensory analysis contributes to the development of a comprehensive set of professional competencies, including digital literacy, critical thinking, management of large data sets, evidence-based technological decision-making, and the ability to adapt to the ongoing innovative transformation of the food industry. This approach aligns with the modern requirements for training specialists capable of performing effectively in a high-tech production environment and a digital economy.

Conclusions. This study demonstrates that integrating neural network technologies into the methodology of teaching sensory analysis offers an effective and promising approach for modernizing the professional training of food technologists. An analysis of the current use of artificial intelligence in educational contexts reveals the considerable potential of neural network tools to accelerate the learning process, tailor educational pathways to individual needs, automate the processing of sensory research data, and enhance the objectivity of evaluating learning outcomes.

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The examination of the methodological aspects of sensory analysis training shows that traditional approaches, which primarily focus on the empirical acquisition of tasting skills, can be significantly enhanced by incorporating intelligent decision-support systems, machine learning techniques for sensory profiling, and digital simulation platforms. Such integration fosters the development of students' analytical thinking, strengthens their predictive reasoning skills, and promotes proficiency in handling large datasets.

The conceptual frameworks for integrating neural network technologies into sensory analysis education have been substantiated. These frameworks are based on the principles of interdisciplinarity and competence-oriented learning and involve the use of adaptive digital platforms, virtual laboratory environments, and automated systems for modeling sensory evaluations. The adoption of these approaches supports the development of professional competencies, including digital literacy, critical interpretation of experimental data, and the application of modern technologies in production environments.

Thus, this study highlights that the integration of neural network technologies into the education of future food technologists is a crucial factor in enhancing educational quality and aligning curricula with the requirements of innovation-driven development in the food industry. Future research should focus on empirically validating the proposed methodological approaches, designing specialized educational platforms, and systematically evaluating their impact on the development of students' professional competencies.

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