

**IMPROVING MEASUREMENT ACCURACY AND QUALITY MONITORING
SYSTEMS IN ZERO-WASTE FOOD PRODUCTION**

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Annotation: This article analyzes the issues of improving measurement accuracy and quality monitoring systems in zero-waste food production processes. High-accuracy measurements not only ensure optimal use of resources but also guarantee the quality of the produced goods. The automation and integration of quality monitoring systems with digital technologies expand the capabilities of real-time control and analysis.

Keywords: Zero-waste production, metrological accuracy, food industry, quality monitoring, automated systems.

In modern food industries, reducing waste is not only environmentally important but also economically beneficial. Every kilogram of resources should be used to its maximum potential. For this, measurement accuracy and quality monitoring play a vital role. This article scientifically explores the impact of metrological approaches, automated monitoring systems, and real-time control technologies on zero-waste production.

Zero-Waste Food Production: Core Principles

Zero-waste production refers to the approach of maximizing the use of raw materials, water, and energy while returning excess waste to the production cycle through recycling. This method reduces environmental pollution, lowers product costs, and ensures sustainable production.

Main Principles:

- Recycling
- Reusing
- Reduction of residual waste
- Digital monitoring for process optimization

Measurement Accuracy: Metrological Approach

Measurement accuracy is crucial for controlling product quality, especially in:

- Correct determination of ingredient amounts
- Measurement of energy and water consumption
- Control of packaging weight and volume

Modern Instruments:



- Mass flow meters
- Digital sensors (pH, moisture, temperature)
- IoT-based measuring devices

Example: In Nestlé, production lines are monitored using IoT-based sensors to improve measurement accuracy, which has reduced waste by 20%.

Quality Monitoring Systems and Their Automation

Advantages of Automated Monitoring Systems:

- Continuous and real-time control
- Low error rates
- Systems free from human factors
- Quality management based on statistical analysis

Common Methods:

- **SPC (Statistical Process Control)** – detects process deviations
- **HACCP (Hazard Analysis and Critical Control Points)** – monitors critical points for food safety
- **AI systems** – visually inspect product quality (e.g., automatic detection of stains on packaged products)

Role of Digital Technologies

Digital technologies are central in zero-waste production. They allow:

- Fast and reliable data analysis
- Optimization of resource consumption
- Integration between various processes

Practical Example: Using Siemens MindSphere, food enterprises conduct real-time monitoring and achieve 15% energy savings in products.

International Experience

Country	Approach	Result
Germany	Use of digital sensors	Waste reduced by 25%
Japan	SPC + HACCP systems	Errors in product quality reduced by 30%
USA	IoT + Artificial Intelligence	Control accuracy reached 95%

Recommendations for Local Industry

In Uzbekistan’s food industry, the transition to zero-waste production is being implemented step-by-step. The following are important:

- Modernization of metrological services
- Training qualified personnel in quality control
- Providing technical support to local manufacturers

Conclusion

Improving measurement accuracy and quality monitoring systems is one of the key components in zero-waste food production. With high-precision metrological instruments, digital technologies, and automated monitoring systems, it is possible not only to reduce waste but also to consistently maintain product quality. Taking international experiences into account, such systems should be widely implemented in the local industry as well.



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