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APPLICATION OF THE HACCP SYSTEM TO ENSURE THE QUALITY OF MILLING WHEAT STORED IN SILOBAGS

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ABSTRACT

Currently, milling wheat is stored using improved methods, such as Silobag storage systems, which offer the advantage of being managed as ecosystems, thereby considerably reducing quality degradation.

In order to maintain food safety in wheat production, it is important to monitor the risk factors that can affect the safety of the final product. In this regard, the objectives of the study focus on establishing a HACCP monitoring system for each stage of wheat storage in Silobags, defining control points (CP) and critical control points (CCP), as well as the types of potential hazards, within Agroexpert Industry SRL, Dolj, Romania."

INTRODUCTION

From harvest to the consumer's plate, cereals can be exposed to hazards such as pesticides and heavy metals, biological risks such as aflatoxins and pathogens, and physical pollutants present during handling and storage (Hakme et al., 2024; Tsagkaris et al., 2021). These risks highlight the necessity of monitoring and establishing food safety measures to ensure that wheat and its derived products remain safe for consumption (Saeed et al., 2023, de Moraes et al., 2025).

Wheat is a seasonal crop, cultivated once a year, whereas the demand for this grain is distributed throughout the entire year, which is why finding storage solutions is vital to ensuring a constant supply (Suleiman & Rosentrater, 2022). One of these possibilities is Silobag storage, which consists of a ground-level silo made of a large, 7-layer, high-density polyethene bag that is both durable and flexible, specifically designed for storing grains and forage.

From the very first contact between the wheat and the storage space, potential chemical, biological, or physical hazards, or the risk of cross-contamination, may arise (Thielecke et al., 2018).

Physical risk factors in wheat pose a major concern in food safety management (HACCP), as they can seriously threaten consumer health and compromise the quality of products made from wheat or wheat by-products. These are represented by foreign materials (straw residues or other plant debris, sand or soil particles, stones, insect fragments, rodent droppings, metal fragments, plastic, or glass) that accidentally enter the silo at different stages of the supply chain

(Onyeaka et al., 2023) and can lead to severe incidents, compromising consumer safety (Payne et al., 2023). Biological risk factors include microorganisms such as bacteria, yeasts, viruses, molds, and parasites, which can infiltrate the storage facility and become sources of contamination, with repercussions on consumer health (Awuchi, 2023; Martínez et al., 2026). One of the most strictly monitored risk categories associated with wheat is the chemical one, which includes pesticide residues, processing contaminants, and heavy metals (Kovač et al., 2021, Benkerroum, 2020). Improper hygiene or wheat processing can negatively influence storage quality (Stankovich et al., 2023). Given the presence of heavy metals in wheat storage, monitoring them is a significant concern for consumer safety due to the adverse effects of exposure (Briffa et al., 2020).

This study presents an application method for the HACCP system to reduce chemical, physical, or biological risks while minimising adverse effects on the quality and nutritional properties of wheat, with the aim of obtaining high-quality flour for subsequent use in bakery facilities.

MATERIAL AND METHODS

Breadmaking wheat plays an important role in human nutrition, serving as one of the most significant food raw materials globally, both for its nutritional value and its versatility in the food industry.

The Silobag storage system is increasingly used in our country as well, because it offers preservation of wheat quality and long-term durability, increased economic efficiency, airtight storage, and placement flexibility. The monitoring procedure consists of periodic inspections of the wheat silobag to prevent and detect punctures, and the use of sampling ports to collect samples for laboratory tests and to assess the overall condition of the wheat grains (Figure 1.1).



Figure 1 Silobag storage system

The HACCP monitoring system for the Silobag storage of breadmaking wheat at Agroexpert Industry SRL was implemented in accordance with the principles and steps of the HACCP quality assurance system.

RESULTS AND DISCUSSIONS

The monitoring specified in the HACCP quality manual implemented in this study began with a description of the raw material (wheat) and extended to the current legislative provisions governing wheat safety in storage, which are aligned with national and international standards (Table 1).

Table 1.

HACCP system steps applied in the silobag storage facility

Stage	Actions and Documents
1 -HACCP Team	Establishing the team and system coordination
2- Process Identification	Flow diagram / Manufacturing diagram Hazard analysis
3- Establishing CCP	CCP Identification and monitoring
4- Records	Information collection
5-HACCP Oversight	Implementation of Corrective Actions
6- Continuous Improvement	Identification of new hazards (changes affecting the product, process, material)

The purpose of establishing a reliable monitoring system is to implement risk-reduction strategies and define best practices to minimise or eliminate risks, aiming to maintain the safety of breadmaking wheat from harvest and storage through to final use. The objective is the continuous improvement of food safety and ensuring the integrity of the wheat grains, so they can provide valuable components for the food industry.

In this context, the monitoring and documentation systems of the HACCP quality manual were established and combined with field data analysis, ensuring that the analysis leads to the prevention of wheat degradation in Silobags, regardless of the origin of the restrictive factors present (chemical, physical, or biological) - Table 2.

Table 2

Identification of the main hazards arising and their monitoring

Hazard Type*	Factor / Agent	Root Cause	Effects on Wheat / Health	Preventive Measures
F	Foreign bodies (stones, metal, glass)	Improper harvesting and handling	Contamination, equipment damage	Cleaning, sifting, use of magnets
F	High moisture	Storage under improper conditions	Molding, self-heating	Drying to optimal moisture content (≈13-14%)
F	High temperature	Poor ventilation	Degradation, fire hazard	Monitoring and aeration
F	Compaction/pressure	Storage in thick layers	Reduced air circulation	Proper management of the grain mass
B	Molds (*Aspergillus*, *Penicillium*, *Fusarium*)	High moisture and temperature	Mycotoxins, quality spoilage	Moisture control, ventilation
B	Insects (weevils, beetles)	Poor hygiene, previously contaminated storage	Quantitative and qualitative losses	Disinfestation, monitoring
B	Rodents	Non-airtight spaces	Biological contamination, losses	Rodent control (deratization), sealing

B	Bacteria	High moisture	Fermentation, unpleasant odor	Control of storage conditions
C	Mycotoxins (aflatoxins, etc.)	Mold growth	Toxic to consumers	Testing and mold prevention
C	Pesticide residues	Incorrect application	Health risk	Compliance with regulations
C	Fumigants (phosphine, etc.)	Uncontrolled use	Toxicity to workers	Controlled handling, PPE
C	Oxidation / self-heating	Moisture + biological activity	Decrease in quality, fire hazard	Temperature monitoring

**F = Physical, B = Biological, C = Chemical*

The stages constituting potential CCP were identified using the questions from the decision tree, with the data recorded in Table 2, going step-by-step through the flow diagram of wheat siloing/storage.

Quality parameters (moisture, protein, gluten, test weight, sedimentation index) and impurities were determined during storage to ensure that the resulting specifications comply with the standard (Table 3).

Table 3.

Qualitative analysis of wheat kept in silobag storage

Sample	Characteristics				
	Moisture (%)	Protein (%)	Wet Gluten (%)	Test Weight (kg/hl)	Sedimentation Index (ml)
	11.5	12.4	25.6	79.5	33.4

Following the laboratory determinations, the results are recorded in the analysis report, and monitoring charts for the wheat in the silobag are established to prevent hazards.

After step-by-step monitoring of the siloing process, the control points, or critical control points, where intervention is required are established (Table 4).

It can be observed that the critical control points were identified at reception (comprising biological hazard (mold, mycotoxins) (CCP1_B), chemical hazard (pesticide residues) (CCP1_C), and physical hazard (organic impurities such as straw, chaff, dust, etc.) (CCP1_F)). During drying, the hazards CCP3_B and CCP3_C are significant. During silobag storage, the biological hazard (CCP4_B) may persist.

Table 4.

Main hazards identified in silobag wheat storage

Identified stages	Hazard Type*		
	Biological	Chemical	Physical
Wheat reception	CCP1_B	CCP1_C	CCP1_F
Cleaning/conditioning			CCP2_F
Drying	CCP3_B	CCP3_C	
Silobag storage	CCP4_B	CCP4_C	CCP4F
Preparation according to contractual requirements	CP	CP	CP
Shipping and delivery	CP	CP	CP

**CP- control point, CCP- critical control point*

Additionally, a physical hazard (CCP4_F) may exist during storage, caused by the presence of wheat-specific insects or other organic impurities carried over from reception; in this context, the use of chemical substances (insecticides) to minimise this risk may lead to a chemical hazard within the wheat grain mass (CCP4_C).

Consequently, the efficiency of the Silobag storage system is highlighted, as biological activity and fungal development are restricted by the environment it creates.

CONCLUSIONS

The efficiency of the Silobag storage system is demonstrated through the application of HACCP principles and the monitoring of potential hazards, making it highly recommended as a storage method that preserves wheat quality for up to 2 years, with lower storage costs than warehouse storage or vertical cylindrical silos.

Thus, the HACCP system provides a clear approach to food safety in wheat storage through systematic preventive methods that protect consumers from biological, chemical, and physical hazards, utilising precise methods of food monitoring and control.

By focusing on technological advancements, climate change adaptation, and the application of risk-prevention systems (HACCP), the storage process can contribute to a high-quality wheat supply and significantly improve the preservation of baking-flour parameters.

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