

# Supply Chain Management to Maintain Microbiological Integrity of Processed Grain Ingredients



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**G**rain milling is a complex process with many steps. Standard equipment used in milling presents challenges to maintenance of the microbiological quality of grain ingredients that have been processed to achieve a reduced microbiological profile. Grain is received, cleaned, and conditioned for ease of processing and to remove foreign materials and poor-quality or infested kernels before it is milled into flour. Cleaning is performed using an assortment of machines that utilize air currents, magnets, and screens to separate the grain from the chaff and other undesirable materials and foreign substances. Conditioning, or tempering, adjusts the moisture level in the grain to facilitate milling and help obtain maximum separation of the bran from the endosperm. After the grain is conditioned, it can be milled, which consists of grinding and further separation steps. During milling the endosperm is

gradually reduced in particle size by running it between a series of steel rollers and then separated from the bran and germ by running it over sieves. After milling, the flour and other potential minor ingredients are blended to produce various grades of product. In the final step, the product is sifted and sent to bin storage, where it awaits transport to the customer.

Once a lethality step aimed at reducing pathogens is added to this process, the microbiological integrity of the ingredient must be maintained throughout the rest of the process (4). Any milling steps postlethality step increase the risk of product recontamination; therefore, postlethality systems should be dedicated. In addition to dedicated postlethality systems, there are several other considerations to keep in mind for maintenance of the microbiological integrity of processed grain ingredients after a lethality step.

## Good Manufacturing Practices

Good Manufacturing Practices (GMPs) are practices and procedures performed by food processors that directly affect the safety and quality of a food product. GMPs may refer to people, equipment, process, or environment. Postlethality

production areas should be maintained at a higher hygienic level compared with other areas of the mill. This requires an increased level of GMPs to prevent cross-contamination, e.g., footwear control and hand washing prior to entry into the area and employee outer garment control so pathogens are not transferred from one area to another. Personal protective equipment should be housed and used only in the postlethality area. Employees, equipment, and tools (both mechanical and cleaning) should also be dedicated to the area. Visitors and contractors should be made aware of all GMPs and should be held to the same rules as employees entering the postlethality area.

## Sanitary Equipment Design

Sanitary equipment design is the application of equipment design principles that are essential to the timely and successful cleaning of food processing equipment. Dedicated postlethality handling equipment should be designed with these principles in mind. Based on standards established by the American Meat Institute, there are several sanitary design principles that can be applied when designing equipment for foods produced in

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low-moisture environments, such as grain ingredients. The first principle is separation of raw, unprocessed grain ingredients from the postlethality finished processed grain. Food plants should have physical separation between raw and postlethality areas, including personnel, air-handling systems, equipment, locker rooms, or other scenarios in which microorganisms could be transferred from the raw, unprocessed ingredients area to the postlethality area.

The second principle states that equipment must be cleanable. Food equipment must be constructed to ensure effective and efficient cleaning over the life of the equipment to prevent microbial and insect ingress, survival, growth, and reproduction on product- and non-product-contact surfaces. This principle also applies to the processing area, including walls, floors, ceilings, doors, and insulation. Construction materials used for structures must be completely compatible with the product, environment, cleaning materials used, and method of cleaning. Equipment should have smooth surfaces and be accessible to those responsible for cleaning it. All parts of the product zone should be free of pits, cracks, corrosion, recesses, open seams, gaps, lap seams, protruding ledges, inside threads, bolt rivets, and dead ends. These parts should be readily accessible for cleaning and inspection and be easily disassembled for cleaning with minimal use of tools. Equipment should also be designed to be self-draining to assure that no product can accumulate or pool to prevent bacterial harborage. The framework on equipment should not be penetrated, and hollow areas on or in the equipment should be eliminated wherever possible or permanently sealed. Construction assembly materials (bolts, mounting plates, brackets, etc.) must be continuously welded to the surface and not attached via drilled and tapped holes. Penetrating the framework of the equipment provides access points where bacteria could enter and thrive, subsequently contaminating the processing environment and potentially the finished product.

### **Validated Cleaning and Sanitizing Protocols**

Not only is the design of the equipment important for sanitation, the cleaning and sanitizing protocols used are equally important for maintaining the microbiological integrity of grain ingredients. Dry cleaning methods

are recommended for equipment in dry milling processes to prevent the establishment of harborage sites. Water used in wet cleaning may support the growth of pathogens in cracks and crevices that can collect water and are difficult to clean (1). Procedures for cleaning and sanitation must be clearly written, designed, and proven effective and efficient through a validation study. A validation study should be completed once the operation is running under normal conditions and should prove that if procedures are properly followed all visible material should be removed from the equipment and microbiological populations should be reduced. The microbiological data obtained during the validation study should be used to establish the optimal frequency of sanitation on an on-going basis.

A sanitation effectiveness program is a key verification tool that should be used to determine and demonstrate the effectiveness of the sanitation procedures used with food processing equipment through physical inspections, microbiological analyses, and documentation of cleaning parameters at specified frequencies. Training of all employees working in the postlethality area who are responsible for cleaning and sanitizing is important to ensure all procedures are properly understood and followed. A preoperational inspection should be performed to verify the cleaning and sanitizing procedures were followed and that the equipment is ready for start-up.

### **Pathogen Environmental Monitoring Program**

A pathogen environmental monitoring (PEM) program is another key program that can be used to help maintain product microbial integrity so there is no recontamination from the process environment. A World Health Organization survey conducted in Europe found cross-contamination during processing to be the most important factor related to the presence of pathogens in prepared foods (3). A survey of food-borne outbreaks in the United Kingdom found cross-contamination to be a significant contributing factor in 32.1% of cases (2). Although it is not possible to prevent the introduction of pathogens into food processing facilities, it is crucial to minimize their presence. A PEM program monitors pathogens in the manufacturing environment under normal operating conditions. Such a program should be well thought

out and aggressively applied. At a minimum, a PEM program should be implemented in the postlethality area of the facility; however, it is best to include the entire facility.

An effective PEM program is a critical tool for measuring the overall effectiveness of the microbiological controls that are in place and in root-cause investigations. A PEM program should be used to enhance practices, eliminate sites of contamination, and correct potential design problems before they pose a risk to the product. Environmental monitoring testing allows for targeted and actionable information to be gathered to reduce the risk of cross-contamination. The use of proper target pathogens should be decided based on the product, the process, and past history. A PEM program is specific to the individual facility under consideration and specific to the individual operations within the facility. There is no one-size-fits-all program. It is also important that employees never be discouraged from finding a positive result. If a pathogen is present in the manufacturing environment, finding it through an aggressive PEM program enables you to do something about it. Employees should be encouraged to find it if it is there.

Both the Grocery Manufacturers of America and the Almond Board of California have provided detailed guidance on developing a robust PEM program in processing environments for low-moisture foods such as grains. These guidance documents include information that covers the PEM zoning concept, environmental sampling techniques, and sample site selection. The number of swabs taken, frequency of swabbing, and location of environmental samples should be determined by the risk levels inherent to the product and process. Areas with high traffic patterns, a history of positive pathogen results, and where microbiologically sensitive raw materials are handled or stored should be sampled at a higher frequency. Particular attention should also be given to postlethality product areas, because this is where the risk of product recontamination is highest. Finally, if a pathogen is detected, the details of possible corrective actions are discussed based on the zone in which the pathogen was found.

### **Air Filtration in Grain Processing**

Air is an integral component in the processing of grains because it is used to

move the product throughout the milling process and during equipment cleaning. The air used in pneumatic conveying systems to move product should not be forgotten as a possible recontamination point in the postlethality process. Proper filtration should be applied so the risk of microbiological contamination by air is reduced. Compressed-air filters, often used for blowing down and cleaning processing equipment, can also be a source of contamination if not properly maintained in postlethality areas.

### Transportation of Ready-to-Eat Grains

Processed grain ingredients are often transported in bulk by truck or railcar. The normal operations for loading trucks and railcars may require additional measures to maintain the microbiological integrity of the product. As with the equipment used in the production process, sanitary design principles should be applied in the design of a transportation vehicle. This could include incorporating fewer hatches, aerators, penetrators, and hoppers to reduce potential microbiological niches. The interior of the trailer or railcar should have a gun barrel-like finish that contains no obstructions that could provide microbial harborage. Additionally, the transportation vehicle should be designed in a manner that allows complete loading to minimize headspace and prevent condensation due to changing environmental conditions, which might allow microbial growth.

Processed grain ingredients should be transported in washed and sanitized trailers and railcars. The washing and sanitation procedures for transportation vehicles should be validated in a manner similar to the washing and sanitation procedures for postlethality equipment used in production. The microbiological

data obtained during the validation study should be used to establish the optimal frequency of sanitation on an on-going basis. The entire washing procedure should be monitored and verified during each wash cycle to confirm every trailer or railcar meets the requirements established by the validation study.

### Conclusions

Addressing postlethality considerations for maintenance of the microbiological integrity of processed grain ingredients enables simplified product traceability, limits product exposure, and prevents product recontamination. By maintaining the microbiological integrity of the finished product, you can guarantee the maximum benefit from a lethality treatment. These measures also provide greater assurance of that you will deliver a safe, wholesome finished product to the consumer.

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