**Background**

Wheat grain is a raw agricultural commodity that can harbor pathogens. Consuming unsafe to eat raw flour products has been linked to multiple outbreaks of foodborne illness and flour recalls. When wheat is milled into flour, some of the pathogens present on the kernel surface are transferred into the flour. Wheat can become contaminated with bacteria at multiple points in the production chain. This makes a treatment step just before the milling process a suitable location for microbial control. Recalls are also expensive for producers to reimburse impacted consumers and can damage the reputation of the producer. Studies have examined using a variety of treatments for flour, but none are an apples-to-apples comparison.

**Objectives**

- Determine cost per hundred weight of flour
- Identify technology with >1.5 log CFU/g kill
- Assess dosing equipment implementation

**Constraints**

- Must not alter flour functionality
- Safe for existing equipment
- Experimental design conforms to mill parameters
- Treatment method implemented into tempering step

**Regulations**

- Organic Certification
- Generally recognized as Safe (GRAS)
- 21 CFR §137.105
- 29 CFR §1910.119
- OSHA standards

**Design Alternatives**

4 Design alternatives were identified for consideration alongside the chlorine gas currently used. These treatments are:

- Bacteriophage from Lesaffre
- Lactic Acid from Corbion
- A proprietary blend from Agri-Neo
- Peracetic Acid from Hydrite

Each design alternative was used in an experiment to compare the effectiveness of each treatment at reducing the microbial load in wheat. Based on consultation with vendors and literature, none of these 4 alternatives are expected to alter flour quality.

**Design Parameters**

A benchtop experiment was used to assess the efficacy of each treatment method. Each treatment was diluted in sterile tap water at a high and a low concentration. The treatments were applied to samples of regular wheat, wheat grain inoculated with Salmonella, and wheat grain inoculated with STEC. The samples were left to temper for 20 hours at ambient temperatures. Following this period, microbial load reduction could be measured. Results from this experiment are summarized in Table 1. Dr. Teresa Bergholz and Yawei Lin in the Department of Food Science and Human Nutrition ran the experiment and provided raw data for the team’s statistical analysis.

**Economics**

Due to the stark differences between the technologies’ implementation equipment, these capital costs were not included in the calculated costs. The costs solely consider the added, ongoing cost of treating wheat flour with the commercial technologies. These costs are variable and depend on the applied concentrations and Mennel’s mill parameters such as moisture content of wheat and weight of wheat entering the tempering process per batch. Sale prices for the technologies were provided by the commercial vendors. Prices were converted through a series of dilution and unit conversion steps into the desired units. Final costs for each respective technology are summarized in Table 2.

**Decision Criteria**

The internal control and four design alternatives were evaluated in a decision matrix based on the following criteria:

- Ease of implementation
- Safety
- Cost per hundred weight of flour
- Microbial load reduction

The first two criteria were selected based on client desire for an implementation that would not inhibit workflow and be destructive to equipment and worker health. The selection of the last two criteria was based on the need for an effective treatment method that would not coincide with an unreasonable financial burden.

**Selected Design**

Treatment D was selected as the most favorable option. Treatment D had a straightforward implementation and was no more harmful than chlorine. Treatment D had the highest average microbial load reduction across all bacteria strains and treatment concentrations. Treatment D also achieved a mean log reduction greater than 1.5 for both Salmonella and Shiga-toxin producing E. Coli (STEC) at the high concentration tested. The cost of Treatment D is $0.4190 per hundred weight of flour, which is substantially higher than the chlorine control that costs $0.0012 per hundred weight. However, this price increase at the production level should only result in a minimal increase at the consumer level. As food safety is the primary objective for this study, a modest price increase is not a concern.

**Select References**


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**Table 1: Average Log Reduction for Salmonella and STEC at High and Low Concentrations (**\( \alpha = 0.05 \))**

<table>
<thead>
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<td>2.109b</td>
<td>0.963b</td>
<td>1.602b</td>
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**Table 2: Calculated costs of the Control and Treatment Alternatives at Provided Experimental Concentrations**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Concentration</th>
<th>Cost/cwt flour ($)</th>
<th>Cost/Batch flour ($)</th>
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