LEVERAGING AGITATING RETORT PROCESSING TO OPTIMIZE PRODUCT QUALITY
**Introduction**

Beyond the primary goal of ensuring product safety, retort process optimization can help minimize retort cycle time and improve finished product quality. But, how do you identify the best combination when there are so many variables – time, temperature, agitation, heating medium? Process Engineers and Food Scientists regularly confront this question during the development of low-acid packaged foods. A well designed process development and sensory testing plan can be an invaluable tool in evaluating all of these processing options.

This paper reviews the work performed by The National Food Lab in executing a series of retort trials on a canned Queso style Macaroni and Cheese (Figure 1), and the subsequent sensory evaluation of this product. Samples were processed in an Allpax Stretch 2402 R&D retort using seven different operational modes (combinations of agitation and speeds). Heat penetration data was collected during all trials and used to calculate process schedules. Products were submitted for sensory evaluation. Results were then compared in an effort to determine the optimal processing parameters.

**Retort Test Design**

The NFL’s Product Innovation team developed a recipe for Queso-style Macaroni and Cheese (penne pasta in a spicy cheese sauce with vegetables) which was used in this experiment as an example of a low acid canned food (Figure 2). Product was batched and packed into 15-ounce (300 x 407) cans.

Cans were processed in The NFL’s Allpax R&D Retort using water spray and seven combinations of agitation and speed: still, end-over-end rotation (5, 10, and 15 revolutions per minute), and gentle motion (30, 60, and 90 strokes per minute) (Table 1). All processes are currently used in commercial production. Eight cans per trial were equipped with thermocouples and temperature data were collected. Retort come-up schedules were identical. Samples were processed until the slowest heating can achieved minimum $F_0 = 6.0$ minutes, then cooled below 130°F.
Narrative Sensory Testing

Narrative Descriptive Analysis was utilized to provide in-depth descriptions of the product sensory characteristics allowing a comparison of the sensory properties of multiple samples. An NFL panel leader and three members of The NFL’s trained descriptive panel participated in these evaluations. The panelists independently evaluated each sample and described the major appearance, aroma, flavor, and texture characteristics of the Still Cook (Reference) sample. They then indicated the specific sensory attributes that differed in the Variant samples and to what degree the Variant samples differed from the Reference sample in the specific attributes noted. In addition, they made note if a Variant sample showed consumer relevant downsides compared to the Reference sample. All of the information collected was based upon a consensus of opinion reached through group discussions under the guidance of the panel leader.

Results

Meaningful differences in processing time, appearance, aroma, flavor, and texture were found among the experimental samples. Processing times are shown in Figure 3 and Sensory results for select products are shown in Table 2.
**Processing Times**

The various agitation methods yielded large differences in processing time. Processing times decreased as agitation speed increased. The total processing time (excluding come up time) ranged from 129 minutes for the Still Cook down to 48 minutes for gentle Motion (90 strokes/minute) (Figure 3).

*Figure 3: Comparisons of Total Processing Times, Still vs. End-Over-End (EoE) vs. Gentle Motion (GM)*

![Processing Time Chart]

**Product Visual Characteristics**

When cans of the Still Cook (Reference) sample were opened, the sample was not evenly distributed; the vegetables were found predominantly in the top half of the can while the cheese and pasta were compressed and stuck to the can walls on the bottom half of the can. In addition, the cheese sauce was slightly darker near the top of the can and there was some visible oil separation.

In contrast, the end-over-end rotation treatments and the gentle motion treatment all showed even distribution of the pasta and vegetables. The product was not stuck to the sides of the cans and there was no visible oil separation. This makes sense; the Still Cook (Reference) sample had the longest heating time and was not moved during processing, so the product settled unevenly and cooked onto the sides of the can, while the end-over-end rotation treatments and the gentle motion treatment were mixed by the retort’s motion during cooking. The gentle Motion
treatments were similar to the Still Cook product in sample distribution; the product was not moved enough to mix the sample thoroughly during these treatments.

The 90 strokes/minute gentle motion sample’s sauce had a moderately more grainy appearance than the Still Cook sample’s sauce. This is likely due to a slight breakdown of the pasta during the 90 strokes/minute back and forth motion retort process. The other Variant samples showed much less graininess than the 90 strokes/minute gentle motion sample.

**Product Flavor and Texture Characteristics**

The flavors of the Still Cook (Reference) sample were characterized as moderate nacho cheese, moderate chemical heat, moderate savory character, moderate salt, slight to moderate bell pepper and chili pepper, slight tomato, slight onion, and slight pasta/starch. The pasta and vegetables were soft and the cheese sauce was moderately thick.

Two gentle Motion variables (30 strokes/minute and 60 strokes/minute back and forth) were the most similar to the Still Cook Reference sample in aroma, flavor, and texture. The rest of the Variants showed less intense nacho cheese and bell pepper notes, more prominent savory notes, and thinner sauce texture to varying degrees. No off-notes were found with the exception of the 90 strokes/minute gentle motion treatment sample; its savory character was less fresh and more chicken-broth like than the other samples.

### Table 2: Sensory Narrative Descriptive Results for Select Products

<table>
<thead>
<tr>
<th>Retort Process</th>
<th>Reference</th>
<th>Test Products - Deviations from Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water spray, Still Cook</td>
<td>Water spray, 15 rpm end-over-end</td>
</tr>
<tr>
<td>Appearance in Can</td>
<td>Some slightly oily liquid on top, golden tan cheese sauce color on top of can, vegetables mostly on top, cheese and pasta compressed and stuck to sides of can on bottom half of can</td>
<td>No liquid on surface, slightly lighter cheese sauce color on top of can, cheese and vegetables evenly distributed, product not stuck to sides of can, slightly lighter sauce on top of can</td>
</tr>
<tr>
<td>Appearance in Bowl</td>
<td>Moderately thick creamy/smooth dark golden yellow cheese sauce, 1-inch tubes of diagonally cut ribbed pasta</td>
<td>Slightly lighter sauce color, slightly more grainy sauce</td>
</tr>
<tr>
<td>Aroma</td>
<td>Moderate nacho cheese, moderate bell pepper, moderate savory aromatic, slight tomato, very slight onion, very slight starch</td>
<td>Slightly less nacho cheese, slightly less bell pepper</td>
</tr>
<tr>
<td>Flavor</td>
<td>Moderate nacho cheese, moderate chemical heat, moderate savory, moderate salt, slight to moderate bell pepper and chili pepper, slight tomato, slight onion, slight starch</td>
<td>Slightly less nacho cheese, moderate savory is slightly more prominent, slightly more pasta/starch</td>
</tr>
<tr>
<td>Texture</td>
<td>Soft pasta, moderately thick and very slightly grainy cheese sauce, soft vegetables</td>
<td>Slightly thinner sauce, very slightly firmer pasta</td>
</tr>
<tr>
<td>Diff. from Reference</td>
<td>REFERENCE</td>
<td>Slight Difference</td>
</tr>
<tr>
<td>Consumer Relevance</td>
<td>REFERENCE</td>
<td>Acceptable Alternative</td>
</tr>
</tbody>
</table>
Conclusion

Determining optimal processing parameters is not a straight forward task. In this paper, the two fastest processing methods each resulted in approximately a 60% total processing time reduction, but each had very different sensory results (Table 2). The end-over-end (15 rotations per minute) showed only slight differences versus the Reference sample; while the gentle Motion (90 strokes per minute) showed noticeable consumer relevant downsides. Please note that these results pertain only to these specific combinations of formula, packaging, and processing. Changing any of these variables may result in different outcomes.

As new food products are developed, it is important to pay sufficient attention to the identification, development, and testing of processing parameters in order to maximize product quality, minimize retort time, and to optimize the combination of both. Conducting processing and sensory trials, similar to those summarized in this paper, can be a valuable asset in achieving these goals.

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