Development of Manufacturing Model for Popped Snacks (Under NDA)
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Client: Nestlé Nutrition Faculty Advisor: Kirk Dolan, Ph. D

Background
Nestlé is one of the largest food manufacturers in the world. Gerber, one of their eight operating companies, utilizes the design. Gerber sells nutritional products for youth consumers between the development stages of newborn to preschool.

The problem is to create a food manufacturing model to end client’s dependence on co-manufacturing that can be adjusted for regional differences. The model will allow for global sales of a US only snack brand, called Gerber Organic Popped Crisps. Nestlé is looking to improve their overall supply chain by introducing regional finishing sites which will create a more economical, global expansion. They are also looking to create a single, reusable line based on regional specifications from global forecasts.

The snack is created in multiple steps. By moving the product production line in-house, there will be two separate manufacturing lines that will be utilized to create the final popped snack product. The initial semi-finished pellet will be created using extrusion technology at the centralized plant. Pellets would ship from the centralized plant to the regional finishing sites, which is the starting point for this project (Figure 1).

Design Alternatives
Four equipment decision matrices were created to evaluate which equipment can best accommodate regional and product needs. Each equipment decision matrix was dedicated to the four major equipment types: mixer, puffers, seasoning drums, and packaging. Puffing equipment was further divided into two categories: hot air and compression. When evaluating the equipment, there were several criteria that were considered to satisfy the objectives and constraints:

- **Volumetric flow capacity** was the top priority because this determines whether the equipment would meet the required regional throughput in kg/hr.
- **Cost** was the second highest consideration because the equipment must have a payback period under 3 years.
- **Stock Keeping Unit (SKU) flexibility** ensures that the equipment can process a variety of different products.
- **Ease to clean** ensures that equipment is cleaned efficiently, according to sanitary standards.
- **Competitiveness and quality** of the equipment were also considered.

After weighing the criteria on a scale of 1-10, with 10 being the most effective, the line in Figure 2 was produced:

- **Objective**
  - Reduce the cost per bag of $0.13 by 20%
  - Design one line with the flexibility to support four different regions, categorized by expected demands

- **Constraints**
  - Achieve objectives in 6 months from project start
  - Payback period is ≤ 3 years
  - Consider market forecasts for 2024 global expansion of brand

- **Model accommodates product properties**
  - Diameter of un-puffed pellet: 6-8 mm
  - Diameter of product puffed by hot air: 10-14 mm
  - Diameter of product puffed by compression: 25 or 42 mm
  - Bulk density: 860 kg/m³

- **Design is flexible for conventional and allergen variations**

- **GMA Equipment Design Checklist for Low Moisture Foods.** (for square footage and logistics)

- **Complies with cGMP and HACCP.** (for facility design and equipment selection)

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Selected Design
Deliverables the team provided Nestlé included a mass balance, a piping and instrumentation diagram (P&ID), a controls description, an operational description, an economic analysis, and a sensitivity analysis.

- **Mass Balance**
  - Made using future market predictions
  - After completing Table 1, it was determined that, in order to reach the volumetric need, two distinct lines will be needed

<table>
<thead>
<tr>
<th>Region 1 Mass Balance</th>
<th>Hot Air Puffer</th>
<th>Compression Puffer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity (kg/hr)</td>
<td>1 88-29,000</td>
<td>1 18-3,300</td>
</tr>
<tr>
<td>Rate (kg/hr)</td>
<td>504-402</td>
<td>440</td>
</tr>
<tr>
<td>Operational Capacity (%)</td>
<td>Puffing Line</td>
<td>Puffing Line</td>
</tr>
<tr>
<td>Reduced to 56-71</td>
<td>85-94</td>
<td>70-88</td>
</tr>
</tbody>
</table>

- **Economics & Sensitivity Analysis**

To assemble Table 2, it was necessary to separate anticipated costs into fixed and variable categories. From that point, calculations were made. Cost per Bag (CPB) needed to be reduced to $0.10/bag (or 20% of existing CPB, which is currently the profit margin paid to the co-manufacturer). A combined payback period (pp) of 2.69 yrs meets the client’s objective. The Break-Even Point (BEP) is low when compared to the annual quantity produced. This indicates that the design will be profitable.

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- **Sensitivity Analysis**

Three anticipated costs (equipment lifetime, water quantity, and dedicated labor) were chosen to see what impact they have on CPB when. Their cost values were manipulated by ± 20%. A change in equipment lifetime exerts the greatest influence on CPB, as seen in Figure 4.

- **Conclusion**

Within the constraints, the two objectives were met. At project completion, the client received a request from another Nestlé subsidiary. A mass balance for popped chips was needed at several different line sizing’s. Due to the similarity in projects, the client forwarded deliverables made by Baby Snack Pack. For future work, accuracy can be assessed in the economic analysis. The production plan can be expanded into the three other regions considered when selecting a regional finishing site.

- **References**