Process and Plant Design of Low-Carb Bagel Production

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Problem Statement:

o The demand for bagel production has increased due to consumer demand for the product.
o New low-carbohydrate diets have been introduced making a low-carb bagel a desirable commodity.
o With a new recipe, an efficient plant process must be developed for production with small scale experimental data and results.
o Using the experiments and cost estimations, the overall economics will be the final step to the design of this bagel production.

Objective:

- Formulate recipe incorporating low carbohydrate principals for the new and popular low carb diets
- Design most cost and energy efficient plant scale process for bagel production

Ingredients	Pounds	Ounces	Kilograms	%	Scale-up x500
Strong Spring Wheat Flour	6	4	2.834952	61.35%	1417.476
Water	3	2	1.417476	30.67%	708.738
Granulated Sugar		6	0.17009712	3.68%	85.04856
Yeast		1.75	0.04961166	1.07%	24.80583
Salt		1.75	0.04961166	1.07%	24.80583
Vegetable Oil		3.5	0.09922332	2.15%	49.61166
Total	10	3	4.62097176	100.00%	2310.48588

Experiments:

- Experiment 1: All-purpose flour used with a boiling step before baking
- Experiment 2: All-purpose flour used without a boiling step before baking
- Experiment 3: All-purpose flour used without a boiling step and a covering of water before baking to create a crisp texture
  - These experiments used to perfect 'before baking' process design.

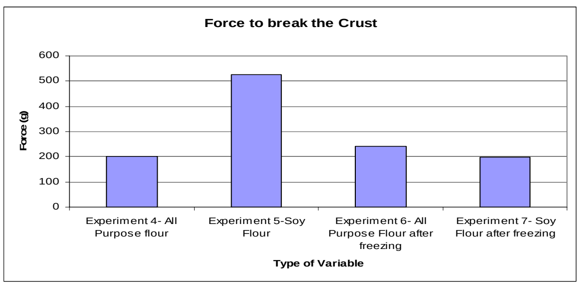
- Experiment 4: All-purpose flour baked with a bowl of water in stove to simulate steaming (used in production)
- Experiment 5: 50% all-purpose flour, 50% soy flour baked with a bowl of water in stove to steam bagels
- Experiment 6: All-purpose flour dough, saved from Experiment 4 and frozen for a week before baking with water in stove for steaming
- Experiment 7: 50% all-purpose flour dough, saved from Experiment 5 and frozen for a week before baking with water in stove for steaming

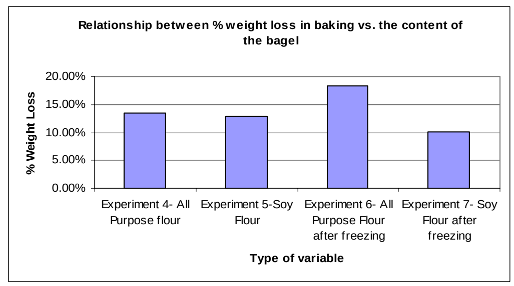
Results

Experiments 1, 2, 3

- Concluded that boiling could be eliminated because of satisfactory sensory results.
- Bagels were crusty and soft.
- Figures below show the three main steps preformed.
  - Raising, boiling, view of after boiling, and baking.





Results

Experiments 4, 5, 6, 7

- Texture and percentage of weight loss were measure to detect which bagel would perform better.
- 50% soy flour held the strongest force to break the crust followed by all purpose, all purpose after freezing and then soy after freezing.
- The weight before and after baking were measured to investigate how the bagel would perform in operating conditions.
- All purpose flour after freezing loss the most weight, while soy after freezing maintained the smallest weight loss.

Discussion of Results

Experiments 1, 2, 3

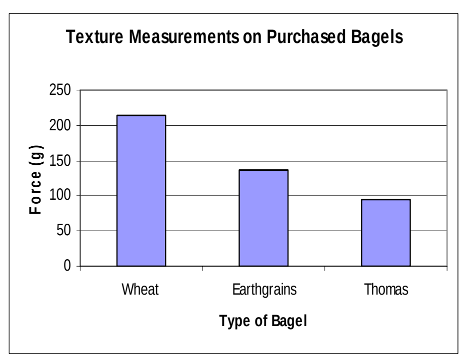
- Determined the boiling step could be eliminated if another type of moisture transfer was implanted.

Experiments 4, 5, 6, 7

- Determined the 50% soy bagel after freezing provided the smallest weight loss between rising and baking.
- The softest texture occurred in the 50% soy after freezing bagel.
- A texture sample of store bought bagel was done to determine an accurate and acceptable range.

Industry Acceptable Range

Wheat: 213.7 g
Plain (All Purpose): 115.7g



Plan for Future Work:

•Create bagels with 100% all-purpose flour, 50% all-purpose/50% soy flour, and soy flour plus gluten and test the viscoelastic characteristics

•Test texture, dimension changes, and sensory characteristics after varying recipe

•Adjust process parameters such as baking time, temperature, and mixing time to produce bagels with the highest quality

•Test texture, dimension changes, and sensory characteristics after implementing the new process

Plant Scale-Up:

•The initial recipe containing ten pounds of raw ingredients is scaled-up to a batch process containing 2,310 pounds of raw ingredients, a summary of the raw ingredient costs is shown in the figure below

Ingredient	Cost per Batch	Cost per Day	Cost per Year
Wheat flour	$1,061.69	$4,246.76	$1,401,430.80
Yeast	$0.24	$0.96	$316.80
Salt	$16.63	$66.52	$21,951.60
Water	$0.19	$0.76	$250.80
Syrup	$849.43	$3,397.72	$1,121,247.60
Oil	$113.93	$455.72	$150,387.60
Total Cost	$2,042.11	$8,168.44	$2,695,585.20

•It is assumed that there will be a 25% decrease in mass after baking leaving a total mass of 1,733 pounds of bagels product with negligible package mass

• Experiments were initially conducted in a home kitchen in a bench top-type manner. Upon scale-up, the bagels will be manufactured in a full-size industrial production facility

•Equipment used in the facility will be the equipment shown on the Equipment Sizing section of this poster

•The facility will produce 1,320 batches per year with 11,553 bagels per batch, six bagels per package, and a selling price of $2.25 per package

•Total income from the sale of bagels will be $5,718,900 and the total manufacturing cost will be $3,307,164.

•Net Profit will be approximately $2,400,000.

Fixed-Capital Investment, Working Capital, Total Capital Investment	
Direct Costs	**Costs**
Purchased equipment	$103,133.00
Purchased equipment installation	$48,472.51
Instrumentation and controls (installed)	$37,127.88
Piping (installed)	$70,130.44
Electrical systems (installed)	$11,344.63
Buildings (including services)	$18,563.94
Yard Improvements	$10,313.30
Service facilities (installed)	$72,193.10
Total direct plant cost	$371,278.80
Indirect Costs	**Costs**
Engineering and supervision	$34,033.89
Construction expenses	$42,284.53
Legal expenses	$4,125.32
Contractor's fee	$22,689.26
Contingency	$45,378.52
Total indirect plant cost	$148,511.52
Fixed-capital Investment	$519,790.32
Working capital	$91,788.37
Total capital investment	$611,578.69