A technical perspective on challenges in providing nutritious lower calorie snack foods - Case studies on SunChips, Baked Lay’s and future offerings

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The largest hurdle to lower calorie snacks is not taking out the fat...

Consumer Liking

Increased liking

Below this line, Consumer are much less likely to purchase product

Fat reduction (g/1 oz serving)

Decreased liking

It is sustaining the consumer liking of the product...

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Pathway to lower calorie snacks are many

• Optimize frying profile and product surface characteristics to pick up less oil
• Develop non-fried snacks that are great tasting
• Invent new thermal processes that can mimic heat transfer coefficients similar to frying without oil as a medium of heat transfer.

Today we will focus on 2 products as case studies illustrating the above principles and take a look at the future

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Attributes renewed from “Prontos” (late 1970’s Frito-Lay test market product):

1. Concept: better-for-you positioning with at least 25% less fat

2. Shape: Prontos die insert, later upgraded (Prontos was a product tested in late 1970’s, made with multi-grains using an extruder)

Better-for-you product design elements have proven visionary

Three of four grains in multi-grain recipe are whole grains:
- Whole wheat
- Whole milled corn
- Whole oat flour
- Rice flour
SunChips’ Illustrious Product History

1987-1989
Develop & Test market

1990-1991
Launch

1995
Re-launch

1989 Test market 4-to-1 complements-to-complaints!

“Project No. 6”
“Project Amber”
“Project Harvest”
Multi-grain
Cooked in heart healthy Canola oil

1990
Better-for-you “BFY”

1995
“SunChips”
“30% less fat than regular potato chips”

2000

2005
Re-launch

2006-2007
Aberdeen
Topeka
Perry
England

2009
Grainwaves
(PI – Australia)

2010
Casa Grande

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SunChips Process

Wheat Cooking

Wheat Quench

Extruder

Fryer

Seasoning

Packaging

Mixer (Dry Mix)

Water

Moisture Control

Mix batch
Whole corn
Rice flour
Whole oat flour
Sugar
Natural Flavor

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Complexity: In addition to mixing, extruding, frying, and seasoning, SunChips combines two additional operations:

1. **Wheat cooking**: needed to soften whole wheat so it will pass through dies

2. **Corn milling**: to provide fresh whole-milled corn

3. **Heart of process**: extrusion with large distribution die Needed CFD modeling to balance flow across the width
SunChips: Process

Balancing work input, heat/thermal input, gelatinization of starch

Extrusion

A NEW PARADIGM IN MIXING AND COOKING WHOLE GRAINS ALL TO THE SAME DEGREE

- extruder serves two functions:
  - excellent distributive mixing of milled grains, cooked wheat, and added water
  - metering to filter screen and die – large pressure drop results in excess viscous energy dissipation which can overheat the dough

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SunChips: Process

Process Controls – key to delivering accurate quality and meeting legal claims

Fryer control

Dynamic Matrix Controller elevated frying to a whole new level

fryer utilizes multi-input, multi-output model-predictive controller, enabling “30% less fat than PC” label claim

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Baked Lay's – Basis of Interest

- Calories, fat and sodium content are leading indicators for H&W for the US population.
- Over 70 percent of Americans are consuming reduced fat foods – Nat’l Eating Trends research
- Baked is being purchased by all consumers
High Heat Transfer is Critical for Texture

Graph showing moisture percentage over time for Frying, Home Oven, and Minimum needed for Texture.
Product Design Goals

- Texture: crispy, light, airy
- Smaller size appealing to consumers
- Sodium 140 mg in 1 oz serving
- All Natural ingredients
- Consumer Acceptability for Potato Flavor
Chemical Leavening Agents
Provide a Number of Functions in Baking Applications

Four Methods of Leavening
1. Air
2. Steam
3. \( \text{CO}_2 \) from Yeast Fermentation
4. \( \text{CO}_2 \) from acid/base reaction

Chemical Leavening Systems
- Provide lift in Baked Goods via the release of \( \text{CO}_2 \)
  Fast acting leavening agent (off gases in under 60 sec)
- Control Yeast Fermentation
- Reduce proof time
- Modify flavor
- Encourage Maillard Browning Reactions via alkaline system
- Control Color

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SEM Micrographs

- Small Enclosed Air Cells, Thin Walls
- Tunneling
- Thick Area
- Thin Area
- Mostly the same thickness
- Larger Enclosed Air Cells, Thicker Walls

Reference

Leavening Removed
By adjusting process conditions in mixing, we can achieve a range of product textures.

INDEPENDENT VARIABLES

- Ingredients
- Feed Rate
- Water
- RPM
- Screw configuration
- Temperature
Increasing work input leads to a more cohesive dough.

Blisters observed to be more uniform and robust leading to a reduced breakage.
We can compare proposed improved designs by studying the flavor compounds produced during baking.

GC-MS analysis of relevant flavor compounds may provide a ‘roadmap’ of how this technology impacts the flavor reactions for development of toast note.
The work continues with Future Offerings
Overall objectives are to answer consumer experiences

Product Experience
What changes when fat is taken out of our chips?

Physical measures
- Oral processing profile-

Consumer measures
- Sensory profile -

Physiology
- Receptor modeling -

What physical and chemical structures create mouth feel?

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We evaluate various analytical techniques for characterization

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Analytical Techniques</th>
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| Pore size distribution | o Mercury Intrusion  
                         | o BET                             
                         | o Pycnometer                       
                         | o Micro CT- Scan                  |
| Surface topography  | o ESEM                           
                         | o SEM                             
                         | o CLSM                            
                         | o Optical Microscope              |
| Oil distribution    | o CLSM                           
                         | o Raman Spectroscopy              
                         | o Micro CT- Scan                  |
Penetration of liquids into a porous body: If a porous body behaves as an assemblage of very small cylindrical capillaries, the volume which penetrates in $t$ time would be proportional to the square root of $(\gamma t / \eta)$.

Edward Washburn, March 1921

\[ L = \left( \sqrt{\gamma \cos \theta / \eta} \right)^2 \sqrt{r} \sqrt{t} \]

Values used in the calculation are taken from the research paper published by Sam Saguy, 1994 in JFS.

1 degree temperature drop in temperature is approximately 1 psi change in pressure.
We are leveraging CT-scan to study oil distribution

**Background**

- CT stands for Computerized Tomography, where X rays are used to create image on the detector.
- X rays are absorbed differently (attenuation coefficient) by different components (density differences) in a given material.
- Image generated by CT scan has bright spots (high density), gray spots (lower density) and black areas (voids/air).
- Image generated by CT scan can be separated into different density components using various imaging software's.

**CT Scan: Pros**

- Non-invasive technology
- No dyes are required
- Entire piece can be scanned

**CT Scan: Cons**

- Image analysis is time consuming
- No standard methods for our products
- Data analysis methods are complex

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Different snack surfaces will need different approaches
Our scientific understanding of the process and development of analytical tools coupled with technical innovation will deliver snacks that will meet and exceed consumer experience with lower caloric density.