Formulating “Clean Label” Dairy, Non-Std. Dairy, & Non-Dairy Frozen Desserts

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WHAT'S “SPECIAL”/“DIFFERENT” ABOUT FROZEN DESSERTS (e.g., “ICE CREAM” (IC))?

- Critical: The only food(s) that is (are) formulated, manufactured, packaged, distributed, and offered for sale with the full intent of being consumed frozen.

- IC evolved as “clean labeled” (“clean label compatible”)... short, simple, transparent, understandable, consumer friendly terminologies, etc. ...... thru the early 50’s
  - Milk, Sugar, Cream, Natural Flavor

- What's changed?
  - Pressure on “clean labeled” IC’s to remain $$ competitive
  - Return to a “clean label” risking Brand Equities (BE)
  - Create new BE’s via viable “clean label” initiatives
• **Post-WWII:** Standard of Identity for Frozen Dairy Desserts (21 CFR I (B) 135.110 Ice Cream & Frozen Custard); amended early 90's to be compatible with then current labeling law; now...the demands of proposed *increase in serving size*, “added sugars”, etc. Added & inherent stresses (ingredient selection, mfg. conditions, rigors of modern distribution, etc.) to remain compliant & viable.

• Rapid market expansion w/ extended & more complex supply chain: mfg. plant locations vs expanding market location(s).

• Change from “make & serve” to “DSD” to “3rd-party storage, distribution, & sale” and related demands on the products;
• Development of novel ingredients and formulation approaches reflecting then current science & technologies.

• Expanded/more efficient mfg. plants:
  □ Assoc. new processes
  □ New products/formats/forms/flavors
  □ “Need-for-speed” (NPD; rapidly changing markets)
  □ Expanded volumes
  □ Novel packaging technologies
  □ Development of large “re-sale” mix opn’s (one mix serving multiple customers & needs)
  □ Extended production runs.
• Importance of managing overrun (size/strength of air bubble), and water/ice (water/ice/water transition);

• Sensory appeal...maintaining body.texture (textural terms) which "fail first"; demand for more formats, formulations, flavors, inclusions

• Seeking cost mgmt/avoidances/reductions in a constantly competitive and cost sensitive marketplace; managing commodity prices; “line cost averaging”; making more saleable finished IC (reduce losses; increasing yields)

• Concern re compatibility of evolving science/tech to demands re resistance to heat shock, food safety, “all natural” vs “all natural flavors", G-F-Y IC's, etc.) vs key elements of sensory appeal
Add Variations of Theme....

• “IC” (FF, RF, LF, NF, NSA*, NSA*/MF variants, true sugar-free) = ~ 90% of all frozen dairy desserts
  • Sherbet(s)
  • Water ice(s)/Sorbet(s)
• Non-std Dairy (“Frozen Dairy Desserts”; Frozen Yogurt; Frozen “Greek”-style yogurt, etc.)
  • Plant-based “milks”& “recombined” mixes (“Non-dairy Frozen Dessert”)
• Packaged for retail: multi-serve units; single-serve handheld novelties (filled, molded, extruded)
  • Food service: bulk for dip shop delivery; “gelato”
• Food service: “direct draw” soft-serve, frozen yogurts, frozen “Greek” yogurts, shakes, slush, “smoothies”
Consumer Expectations; Sensory Appeal

Regulatory; Terminology; Labeling; Change of Serve Sizes; Min lbs/gal; Fd Safety

Packaging

Opn's: Distrib.

Milk, Sugar, Cream, Natural Flavor

$$ + Ingredient, Fixed/Var Costs, Margins thru Supply Chain, Losses/Yields, LCA, ROI's


/+/- Color*, Flavor(s)*, Particulate (10) &/or Syrup Inclusions (15)

After 50+ years, the ingred list may look like this......
Skim milk, nonfat dry milk, whey, cream, sugar, high fructose corn syrup, corn syrup, guar gum, locust bean gum, cellulose gum, cellulose gel, carrageenan, mono-diglycerides, polysorbate 80, flavor*, color*

Consumer Expectations; Sensory Appeal

Regulatory; Terminology; Labeling; Change of Serve Sizes; Min lbs/gal; Fd Safety

Packaging

Opn's: Distr. Distrib. Fd Safety Opn's:

$$ + Ingredient, Fixed/Var Costs, Margins thru Supply Chain, Losses/Yields, LCA, ROI's


+/– Color*, Flavor(s)*, Particulate (10) &/or Syrup Inclusions (15)
MANAGING THE SUM OF ALL BRAND EQUITIES (Benchmarking BE’s)...

The plane of “all” vanilla IC’s......

Being different in a “be-the-same” marketplace

Brand A

Brand B

Brand C (current?)

Brand C (original?)

- Maintain or reduce differences?
- Enhance/strengthen differences?
- Managing features (facts) to create more reasons-to-buy (benefits)
- BE tolerance vs market demands/distrib/opns/$$?
- As the demand re “clean labeling” rises, the more similar the IC’s, the more difficult to “match” (even to SAME BE)
• RISING RISKS TO CURRENT CORE BRAND EQUITIES (BE)
  □ Brand ID’s; Mrkt Positioning; Features (facts) vs Benefits (reasons to buy);
  □ Pricing: Internals/external accounting policies: IC is priced and sold by vol AND wgt.; add commodity pricing and influence(s) of “line cost averaging”, need for specialty ingredients, expense of inclusions, etc.;
  □ Challenging compositional considerations (the age of “ice milk” thru the evolution/demands of modern nutrition labeling & “clean labeling” initiatives); demands on eating qualities;
  □ Formulating for the rigors of modern IC distribution System
    □ Frozen food (< 0 F)
    □ Frozen desserts (< -20 F distrib/commercial storage; at retail > -10 F; consumed ~ 0 F - +5 F)

• “MATCHING” CURRENT BE VS “CLEAN LABEL” BE
Leveraging Mother Nature’s Rules-of-the-Road …………

• Freezing point of water is depressed relative to the total number of molecules in true solution. Can be formulated, calculated, managed.

• Ice is not a solvent (freeze concentration of solutes in water: +/-’ each solute may/may not reach its solubility limitations; freezing point of any given mix will change due to FC)
  - Lactose will crystallize if > 12-13% in water phase
  - FC influences +/- depending

• Mother Nature provides enough mix emulsification capacity to make a stable mix….so why add emulsifiers? Importance of allowing/managing “fat agglomeration” during whipping/freezing

• Mother Nature likes large things: low “energy” per unit surface area…..air bubbles; fat globules, ice crystals; sugar (lactose, DX) crystals, etc. Runs counter to sensory appeal
Leveraging Mother Nature's Rules-of-the-Road ..........

• Sensory appeal prefers large number of small air bubbles, ice crystals, etc. = below sensory “detection” = the whole perceived as smooth, creamy, rich, etc.

• More/small ice/stable air bubbles supports desirable body/chew, smoothness, creaminess, added resistance to heat shock

• Mechanical approaches & ingredient selection, formulation alternatives, etc. to leverage/manage chemistries and physics?

• Creates multi-variant approaches. considerations, analysis.... Do more “pragmatic” approaches/guidances exist?
Manufacturing Considerations....

- Ingredient “History”: Functionality, Flavor, Influence(s) on Sensory Appeal in the Finished IC (stay tuned)

- Mix Processing
  - Mix assembly
  - Pasteurization times/temps/approaches
  - Homogenization conditions (temp, PSI's, efficiencies, etc.)
  - Mix “Aging”
    - Crystallize MF;
    - Condition surface MF droplet; prep for fat agglomeration (de-stabilization during whipping/freezing)
    - Set “final” mix viscosity;
    - Extend micro shelf-life of the mix;
Manufacturing Considerations/Approaches:

- **Mechanical pre-aeration** (adding air in advance of freezing);

- **More efficient whipping/freezing** (i.e., heat transfer; more influence of freeze conc in advance of fat agglomeration);

- **Lower exit (draw) temperatures** (i.e., “churned” styles): FP mgmt. increases amt. water frozen at any given temp (only limit.....flow properties of IC post whipping/freezing);

- **Rapid hardening** (e.g., novel application of cryogenic gas to harden from the inside out); rapid decrease in IC temp thru the “danger zone”, +15-to-0 F;

- **Minimizing the rigors of distribution** (via ingredient select/form.)
Formulation/Ingredient Approaches....

• Leveraging amt/type/“condition” of fat/composition in original “milk”; considering influence on final food declarations, claims, whipping/freezing, flavor delivery, etc.
  □ Acid Whey = + tart; 100% MSNF = sherbets
  □ UF Wheys (34–94% protein) = partial/total replace skim solids w/ low/no lactose = + WCI (stay tuned)
  □ Sweet Cream Buttermilk = + body/texture/WCI/mild flv. = sherbet (see below)
  □ Sour Cream = Milk fat source = body/texture = all IC’s?
  □ Yogurt/Greek Yogurt (source of MSNF/MF; dry formats & blends) = mid-to-high protein; mild-to-tart flv. = froz. “yogurts”...blend to functional/regulatory need/taste

• Consider naturally occurring lecithin as a source of “emulsification” to help promote fat agglomeration during whipping/freezing; inherently “high” in egg yolk solids and sweet cream buttermilk with precautions related to each.
Formulation/Ingredient Approaches....

• “Fat agglomeration” is critical to eating quality/stability BUT it is “qualitatively” additive; “too much of a good thing is bad.......”

• “Clean label-compatible” sources of sweetness? Sugars, “added sugars”, calories, etc.? Formulating “clean label” compatible NSA/true-sugar-free IC’s

• Calc. dynamics related to targeted market(s), brand ID’s; BE’s

• Body/texture are features that “fail first”: related to multiple variables/considerations; as a whole, define end of “textural shelf-life”;

• Watch for regulatory compliance vs proposed increase in serving size for packaged IC’s (1/2 cup to 2/3 cup; everything currently formulated for 1/2 cup; do current product(s) comply OR need to reform)
Consider The Variety of Ingredient Influences (+/-)

- % Milkfat (MF)... ~ 18% total (MF +) to true “fat free”;
- Amt/type MSNF... Skim solids (+/- allowed alternative(s); hi MW proteins interfere more than micellar/colloidal casein; SCBM = source of “pre-conditioned” proteins, MF, and lecithin)
- Sweetness... Amt/quality = +/- compatibility w/ added "characterizing" flavor(s)?
- Other components/influences that might interfere with flavor intensity/quality/delivery/preferences
  - Flavor of the ingredient(s) (+/- influence via freeze conc.)
  - Body (bite; chew); Texture (smooth/creamy/rich)
  - Delivering the right amt/type flavor component(s) ...aromatics and other components....released/perceived
    - Desired intensity/quality flavor delivery may/may not equate to sensory appeal/preference....
Consider The Variety of Finished IC Influences (+/-)

- Overrun: i.e., lbs. per gal finished IC: size/stability of air bubbles, eating quality, flavor delivery, yields ($$)

- Conditions under which...
  - Ingredients are created, selected, formulated, assembled
  - Mix as processed, stored, flavored
  - Mix as whipped/frozen; packaged; hardened; distributed; sold; consumed including conditions under which the IC is evaluated.

- All the above critical to ultimate flavor/brand equities (BE).....

- Thus, another difficult assignment = “match” (how close is close enough?) vs exist consumer acceptance (BE)
• **Formula Guidances**

- **Final IC#/gal:** +/- 5% OR*; Influences amt./quality/perception of flavor, overall sensory appeal

- **Theoretical Sweetness:** +/- 0.5%*: Is the sweetness compatible with the quality/amount flavor(s) used (+/- lactose?)

- **Freezing Pt Factor (FPF):** +/-5%*: Influences amt water frozen at any given temperature (see TSI); eating quality; heat shock resist

- **Lactose as % in water phase in mix:** < 12% to consistently reduce likelihood of “sandiness” due to lactose

- **Water Control Index (WCI):** +/- 5%; Influences behavior (i.e., flow) of liquid water under the influences of Freeze Conc; may also provide guidance re perception (+/-) of added flavors (WIP)

  - * Set “Control”, “Current”, “Target” vs proposed; WIP
  - * If within range = test/evaluate sensory appeal vs selected “control”: if outside range, reformulate back to within range(s)
• Formula Guidances.....

- Texture Stability Index (TSI): +/- 5% (Amt. water that freezes, thaws, refreezes between any 2 defined temps: measure of resistance to heat shock; closely assoc. with FPF; requires a more rigorous assessment of any given set of mixes)

- Amt. Total Added Flavor (characterizing +/- WONF): +/- 5% (WIP)

- Amt. “Characterizing” Flavor Added: +/- 5%; (WIP)

- Amt. Milk Fat (wgt. per unit volume): +/-5% (CW); a bit more tolerant to “natural flavors” down to ~ 4-5% MF; what about fat alternatives or plant-derived fats/oils? More +/- as < 4% MF. Plant sterols... fat/lipid but only fraction of “fat as TG”....

  - * Set “Control”, “Current”, “Target” vs proposed; WIP
  - * If within range = test/evaluate sensory appeal vs selected “control”: if outside range, reformulate back to within range(s)
  - * OK to start thinking about $$, ,$$ avoidances, $$ savings, $$ yield improvements
<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Current 10% IC</th>
<th>12% IC</th>
<th>14% IC</th>
<th>16% IC</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milkfat</td>
<td>10.0%</td>
<td>12.0%</td>
<td>14.0%</td>
<td>16.0%</td>
<td>Min 10% MF</td>
</tr>
<tr>
<td>Skim Solids</td>
<td>7.5%</td>
<td>5.5%</td>
<td>5.5%</td>
<td>5.0%</td>
<td>Min 20% total Milk Solids</td>
</tr>
<tr>
<td>B-milk Solids</td>
<td>2.5%</td>
<td>5.5%</td>
<td>5.5%</td>
<td>5.0%</td>
<td>OK as portion of MSNF</td>
</tr>
<tr>
<td>Sweet Whey</td>
<td></td>
<td>2.5%</td>
<td>5.5%</td>
<td>5.5%</td>
<td>Whey ingred up to max 25% of total MSNF</td>
</tr>
<tr>
<td>Sucrose</td>
<td>12.0%</td>
<td>14.0%</td>
<td>15.0%</td>
<td>14.0%</td>
<td></td>
</tr>
<tr>
<td>36 DE CSS</td>
<td>6.0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S/E</td>
<td>0.3%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Solids</td>
<td>38.3%</td>
<td>37.0%</td>
<td>40.0%</td>
<td>40.0%</td>
<td></td>
</tr>
</tbody>
</table>

Outside “guidances” in red

<table>
<thead>
<tr>
<th>Property</th>
<th>Current 10% IC</th>
<th>12% IC</th>
<th>14% IC</th>
<th>16% IC</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweetness, %</td>
<td>15.9</td>
<td>15.2</td>
<td>16.2</td>
<td>15.2</td>
<td>+/- 0.5% (15.4-16.3) **</td>
</tr>
<tr>
<td>Lactose, %</td>
<td>9.7</td>
<td>9.6</td>
<td>10.1</td>
<td>10.3</td>
<td>Lactose % in water &lt; 12%</td>
</tr>
<tr>
<td>FPF**</td>
<td>22.4</td>
<td>20.0</td>
<td>21.0</td>
<td>19.5</td>
<td>+/- 5.0% (20-23) **</td>
</tr>
<tr>
<td>WCI *</td>
<td>59</td>
<td>57</td>
<td>57</td>
<td>52</td>
<td>+/- 5.0% (56-62)**</td>
</tr>
<tr>
<td>TSI</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD as FPF &gt; +/- 5%</td>
</tr>
<tr>
<td>#/gal mix</td>
<td>9.22</td>
<td>9.08</td>
<td>9.10</td>
<td>9.05</td>
<td>See OR</td>
</tr>
<tr>
<td>#/gal IC</td>
<td>4.60</td>
<td>4.55</td>
<td>4.55</td>
<td>4.50</td>
<td>Reg Min = 4.5 #/gal</td>
</tr>
<tr>
<td>OR (calc)</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>+/- 5%</td>
</tr>
<tr>
<td>$ per gal IC</td>
<td>$1.12</td>
<td>$1.07</td>
<td>$1.17</td>
<td>$1.20</td>
<td>Mix Ingred. $$ Only*</td>
</tr>
<tr>
<td>Lbs MF/gal IC</td>
<td>0.46</td>
<td>0.55</td>
<td>0.64</td>
<td>0.74</td>
<td>+/- 5% MF (0.44-0.48)</td>
</tr>
</tbody>
</table>

* Managing ”line cost average”: typically IC w/ inclusions > cost IC itself; positioning of product line may/may not allow for specific flavor options.
VEGETABLE "MILK"-BASED NON-DAIRY FROZEN DESSERTS
Vegetable “Milk”-Based Non-dairy Frozen Desserts*

- Nutmeat “Milks”: Almond, Hazelnut, Cashew, Walnut, Peanut, etc.
- Oilseed “Milks”: Soy, Canola, Sunflower, Sesame, Quinoa, Coconut, Pea, Flax
- Grain “Milks”: Barley, Oats, Rice, etc.

- Same principles, guidance(s) per dairy-based products;

- Selection, approach, formulation depends on market positioning: features/benefits (e.g., “clean label”, flax/omega-3; oats/beta-glucan; non-dairy; lactose-free; all-vegetable; vegan; cholesterol-free; etc.)

- Whole nutmeat/seed/grain processes and/or “filled” (i.e., recombined) processes.

- Classical use of functional and sweetener solids to allow ease of mfg., sensory appeal, resistance to heat shock, etc.
Veg “Milk”-based Frozen Dessert Considerations

- Amt./type fat/oil (total; FA distribution; saturation; melt pt; stability; ability to participate in fat agglomeration; flavor; nutritional efficacies, etc.) extracted fat/oil naturally found in plant sourced “milks”; novelty of plant sterols

- Naturally occurring enzyme systems...lipoxygenase(s), lipases, proteases, amylases, etc., that need to be inactivated. Similar to raw fluid dairy; differing enzymes/affects (+/-); more “added sugars” ??

- Solids (protein; carbohydrates) may be incompatible with functional needs, freezing/whipping, nutritional efficacies, sensory appeal, declarations to be made, etc.

- Management of water used in extraction/treatment solids from source (e.g. amt./type solids in almond milk from almonds)
Veg “Milk”-based Frozen Dessert Considerations

- How veg solids “extracted”/conc. (as necessary) critical ....

- Extracted solids may not deliver all critical veg-sourced solids; delivery of insoluble solids

- Water to manage; amt/“quality” (i.e., flavor) of water used

- Amt/condition fat/oil when “milk” created

- Color/flavor: inherently as extracted; influence of freeze concentration (+/-)

- Sweetness/carbs/amt. & type “sugars” when “milk” extracted (+/-)

- Freezing point mgmt...; Necessary with focus on water immobilization, fat agglomeration, color, flavor, the influence of freeze concentration, etc. = guidances much the same as for frozen dairy-based desserts
**Composition* of Select Single-Strength Vegetable “Milks”**

<table>
<thead>
<tr>
<th></th>
<th>Soymilk</th>
<th>Almond Milk</th>
<th>Hazelnut Milk</th>
<th>Coconut Milk**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fat/Oil</strong></td>
<td>~ 1.8-2.0%</td>
<td>~ 0.5-1.0%</td>
<td>~7.0-7.5%</td>
<td>~ 2.0-2.2%</td>
</tr>
<tr>
<td><strong>Protein</strong></td>
<td>~ 3.50%</td>
<td>&lt; 0.50%</td>
<td>~ 0.5-1.0%</td>
<td>None?</td>
</tr>
<tr>
<td><strong>Sugars</strong></td>
<td>~4.00%</td>
<td>&lt; 0.50%</td>
<td>~ 3.0-3.5%</td>
<td>2.5%</td>
</tr>
<tr>
<td><strong>Dietary Fiber</strong>**</td>
<td>~ 1.5-2.0%**%</td>
<td>&lt; 0.10%</td>
<td>Varies</td>
<td>Varies</td>
</tr>
<tr>
<td><strong>Total Solids</strong></td>
<td>~ 10.0-11.5%</td>
<td>~ 1.6-2.0%</td>
<td>~12.0-15.0%</td>
<td>~4.50-4.70%</td>
</tr>
</tbody>
</table>

- Approx. expected compositions; no other added ingredients
- **Coconut “cream” = Conc coconut milk solids (composition varies)**
- ***Dietary fiber = soluble/insoluble; variable; reflects source/extract method;***
# Vegetable (Plant) “Milk”-based Frozen Desserts*

<table>
<thead>
<tr>
<th></th>
<th>Soy</th>
<th>Almond</th>
<th>Hazelnut</th>
<th>Coconut</th>
</tr>
</thead>
<tbody>
<tr>
<td>Veg “Milk” Solids</td>
<td>~9.0-10.0%</td>
<td>~&lt; 2.0 %</td>
<td>~10-12%</td>
<td>~20%</td>
</tr>
<tr>
<td>Fat/Oil**</td>
<td>2.0-3.0%</td>
<td>&gt; 2.0%</td>
<td>Varies</td>
<td>Varies</td>
</tr>
<tr>
<td>Protein**</td>
<td>1.0-2.5%</td>
<td>2.50-3.50%</td>
<td>~2.00%</td>
<td>2.0-2.5%</td>
</tr>
<tr>
<td>Sucrose***</td>
<td>~11.5-12.0%</td>
<td>11.5-12.5%</td>
<td>~12-13%</td>
<td>11.5-12.5%</td>
</tr>
<tr>
<td>Low DE CHO****</td>
<td>6.0-7.0%</td>
<td>8.0-10.0%</td>
<td>5.0-7.0%</td>
<td>6.0-7.0%</td>
</tr>
<tr>
<td>S/E</td>
<td>Per Need</td>
<td>Per Need</td>
<td>Per Need</td>
<td>Per Need</td>
</tr>
<tr>
<td>Total Solids*****</td>
<td>~30-35%</td>
<td>~26-30%</td>
<td>~29-35%</td>
<td>39.5-44.4%</td>
</tr>
</tbody>
</table>

*Starting formulas (compositions will vary)
**Similar or different veg-based fat/oil and/or protein sources;
*** Sucrose +/- other source(s) sweetness; **** Select from low DE carb source(s);
***** TS (+/-) vs desired sensory, freeze pt., water/fat mgmt... principles, final lbs. per gal, etc.
DETAILED, UPDATED COVERAGE, INSIGHTS
Novel Approaches, Ingredient Development,
Selection, +/- Processing Options, WIP’s, etc....

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- 43RD Offering: NORTH AM ED,
  DEC 6-8, 2017, LAS VEGAS, NV

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And... for more details and guidances....

- “THARP & YOUNG ON ICE CREAM: ENCYCLOPEDIC GUIDE TO ICE CREAM SCIENCE AND TECHNOLOGY” (1ST ED; 2012; 400 PAGES; FULLY CROSS-REFERENCED)

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Formulating “Clean Label” Ice Cream & Related Products

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