

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

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CLEAN LABEL CONFERENCE

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) ²
 - 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 yogurts⁶, 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.

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

Milk, Sugar, Cream, Natural Flavor

Amt? Type? Source? Form? +/- ?
History? Functionalities?

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



After 50+ years, the ingred list may look like this.....

*Consumer
Expectations;
Sensory Appeal*



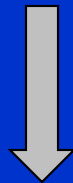
**Regulatory;
Terminology;
Labeling;
Change of
Serve Sizes;
Min lbs/gal;
Fd Safety**



Packaging



**Opn's:
Distrib.**



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



**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***



**Amt? Type? Source? Form? +/- ?
History? Functionalities?**

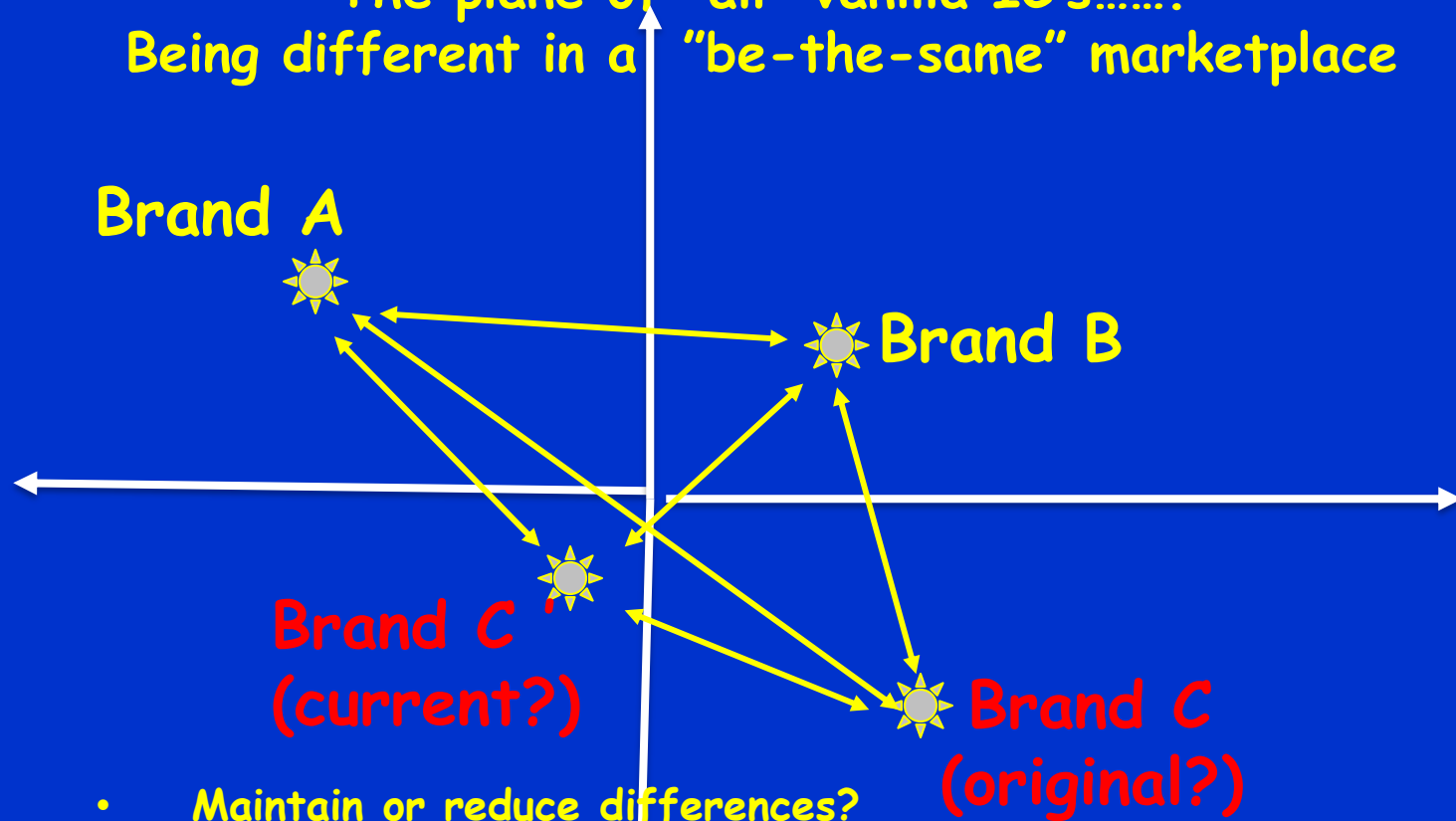
**+/- Color*, Flavor(s)*, Particulate
(10) &/or Syrup Inclusions (15)**

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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



- 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)

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• "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 \geq 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 unit₁ 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;

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- Minimizing the rigors of distribution (via ingredient select/form.)

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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"....

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- * 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

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	Current 10% IC	12% IC	14% IC	16% IC	Notes
Milkfat	10.0%	12.0%	14.0%	16.0%	Min 10% MF Min 20% total Milk Solids OK as portion of MSNF Whey ingred up to max 25 % of total MSNF Outside "guidances" in red
Skim Solids	7.5%	5.5%	5.5%	5.0%	
B-milk Solids		5.5%	5.5%	5.0%	
Sweet Whey	2.5%				
Sucrose	12.0%	14.0%	15.0%	14.0%	
36 DE CSS	6.0%				
S/E	0.3%				
Total Solids	38.3%	37.0%	40.0%	40.0%	
Sweetness, %	15.9	15.2	16.2	15.2	+/- 0.5% (15.4-16.3) **
Lactose, %	9.7	9.6	10.1	10.3	Lactose % in water < 12%
FPF**	22.4	20.0	21.0	19.5	+/- 5.0% (20-23) **
WCI *	59	57	57	52	+/- 5.0% (56-62)**
TSI	TBD	TBD	TBD	TBD	TBD as FPF > +/- 5%
#/gal mix	9.22	9.08	9.10	9.05	See OR
#/gal IC	4.60	4.55	4.55	4.50	Reg Min = 4.5 #/gal
OR (calc)	100%	100%	100%	100%	+/- 5%
\$ per gal IC	\$1.12	\$1.07	\$1.17	\$1.20	Mix Ingred. \$\$ Only*
Lbs MF/gal IC	0.46	0.55	0.64	0.74	+/- 5% MF (0.44-0.48)
* 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"

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

• 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*

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

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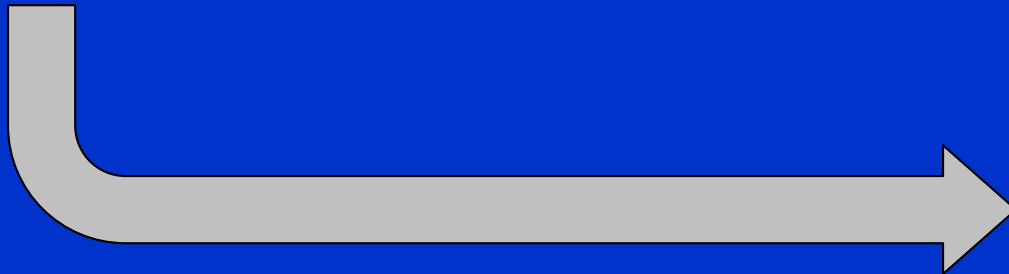
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And... for more details and guidances....

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



**THARP & YOUNG
ON ICE CREAM**

An Encyclopedic Guide
to Ice Cream
Science and Technology



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Formulating "Clean Label" Ice Cream & Related Products

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