

Development of a Software Program for Goal Oriented Formulation

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SUMMARY

New product development of a manufactured food such as a frozen dessert is a complicated process that involves meeting many goals referred to as *goal oriented formulation*. A computer program (the TechWizard™) was developed and tested to facilitate goal oriented formulation. The TechWizard™ computer program successfully predicted many of the appearance, flavor and texture characteristics of ice creams varying in fat content and with or without added fat substitutes. Sensory scores for appearance, icy mouthfeel, and meltability of the ice cream obtained using descriptive analysis correlated well ($R^2 > 0.9$) with the estimated values for percent product frozen (g ice / 100 g product at serving temperature, -13°C). These results demonstrated that the TechWizard™ can be used to aid not only in composition and cost evaluation, but also in the development of a composition to meet sensory and textural response requirements.

INTRODUCTION

Development of a manufactured food such as a frozen dessert is a complicated process that involves meeting many goals. Some of these goals may include matching the flavor and texture of other products of the same type, meeting regulatory requirements of product identity, meeting compositional restrictions for appropriate quality and shelf-life, and meeting cost constraints. We refer to this process as *goal oriented formulation*. The TechWizard™ computer program was designed to facilitate *goal oriented formulation*.

OBJECTIVES:

The objective of this research was to develop and test a computer program (referred to as the TechWizard™) that uses a combinatorial optimization algorithm to aid in new product formulation to achieve required sensory, quality, and compositional goals.

MATERIAL & METHODS

Formula Development, Experiment 1: The TechWizard™ was used to develop ice cream formulas with constant sweetness intensity (16), constant freezing point (-2.45°C), and constant sucrose molecular equivalents (22.2) and varying in fat content (0.1 to 10%).

Formula Development, Experiment 2: The TechWizard™ was used to develop ice cream formulas with the same criteria as Experiment 1 but replacing milk fat with maltodextrin, milk protein concentrate, polydextrose or lactose reduced freeze-concentrated skim milk.

Sensory Analysis: Quantitative descriptive analysis was used to develop a ballot, which was then used by a trained sensory panel to assess appearance, flavor, and texture of the ice creams.

Program Components

» **Goal Oriented & Least Cost Formulation:** One of the more difficult tasks when developing a new formulation is determining how much of each ingredient to use to meet economic, compositional, quality, and flavor goals. We refer to this process as *goal oriented formulation*. The TechWizard™ user interface was designed to make this phase of product development much easier.

Procedure

1. The user selects the ingredients to be used. If a least cost formulation is to be developed, the user enters the current ingredient prices or retrieves the prices from the ingredient database.

- The user enters formula specifications, which represent the goals for this formulation such as fat, total solids, sweetness, etc.
- The TechWizard™ uses a combinatorial optimization algorithm to determine the best blend of ingredients to meet the various goals.

» **Reverse Engineering:** The TechWizard™ was designed to use product analyses results or a product's nutrition label to develop an equivalent formulation.

» **Archiving System:** The TechWizard™ has both formula and ingredient storage components. The entire USDA food composition database is available in TechWizard™ format.

» **Recipe Entry & Batching:** The TechWizard™ was designed to allow any recipe to be entered and its composition evaluated. The user can also prepare a concise print out of the formulation that lists the amount of each ingredient to use plus any corresponding information and instructions.

» **Nutrition Labeling:** The TechWizard™ can prepare a nutrition label and ingredient declaration for any food product.

RESULTS & DISCUSSION

Development of the TechWizard™ Computer Program

The TechWizard™ was developed to provide the following components in one easy to use computer program:

- Goal Oriented & Least Cost Formulation
- Reverse Engineering
- Formula & Ingredient Archiving System
- Recipe Entry & Formula Batching
- Nutrition Labeling

Figure 1. Front panel and main view menu of the TechWizard™ program showing the main components of the program.



Can the TechWizard™ Be Used to Evaluate the Flavor and Texture of a Food Product Prior to Making that Product?

To answer this question, we selected ice cream as our food to study. Ice Cream is a complex, multicomponent system and well suited for fully testing our optimization software.

Experiment 1: Develop specific ice cream formulas that have:

- Similar freezing points (varying less than 0.35 C)

- Constant milk solids not fat
- Constant calculated relative sweetness
- Varying calculated ice contents at serving temperature (-13°C)

This was accomplished using ice cream formulas that vary in fat content and total solids content (Table 1).

Explanation of Terms Used for Evaluating Frozen Desserts

The % water frozen term is the more common term used in relation to frozen desserts. The term can be explained by the following example. If a liquid mix contains 40% total solids then the rest of the mix is water, i.e.; the water content is 60%. If 50% of the water in the mix is frozen (50 % water frozen) then half of the 60% water is frozen meaning that the mix contains 30 g of ice for 100 g of product. This leads us to the other term used to express freezing characteristics, % product frozen. The % product frozen is simply the grams of ice per 100 grams of product. It was first introduced by Dr. Bruce Tharp (Tharp Food Technology, Wayne, PA 19087). A value of 50% product frozen means that it contains 50 grams of ice per 100 grams of product. This is referred to as calculated ice content in figures 2, 3, 4, and 5.

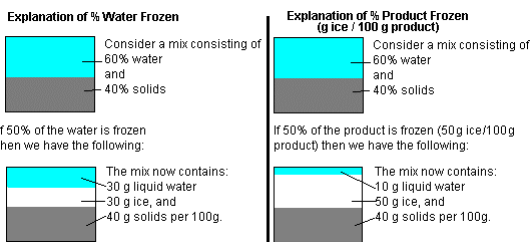


Table 1. Ice cream mix formulations with varying fat percentages.

Ingredient	Fat			
	0.1%	3%	7%	10%
Corn syrup solids (36 DE)	4.50	4.50	4.50	4.50
Sugar	13.05	13.05	13.05	13.05
Vanilla	0.20	0.20	0.20	0.20
Stabilizer	0.20	0.20	0.20	0.20
Cream	0.00	7.40	17.70	25.31
Skim milk	78.15	70.45	59.90	51.83
NDM	4.12	4.45	4.85	5.41
Sucrose equivalents ¹ , %	22.2	22.2	22.2	22.1
Calculated sweetness ² , g/100 g	16.0	16.0	16.0	16.0
Milk SNF	11.0	11.0	11.0	11.0
Total solids, %	28.7	31.5	35.2	38.3
Freezing point ³ , °C	-2.29	-2.38	-2.51	-2.62
Product frozen (-13°C) ^{3,4} , %	56.53	53.78	50.01	46.89

¹The equivalent concentration of sucrose that would cause the same freezing point depression as the sugars, and milk sugars in this mix. ²Sweetness relative to sucrose. ³Calculated values. ⁴Corresponds to temperature at which samples were tempered.

Figure 2. Comparison of Sensory Analysis Scores for Appearance and Sweetness with TechWizard™ Calculated Values for Ice Creams with Varying Fat Content.

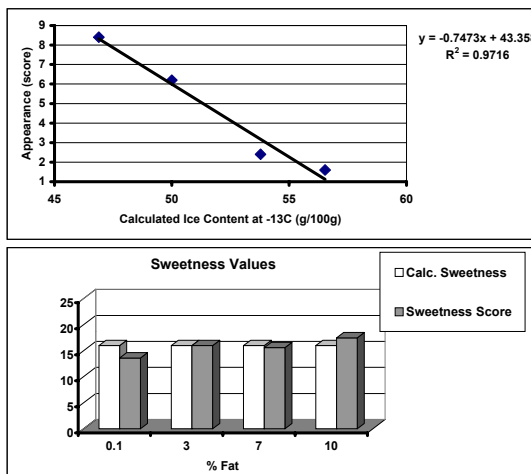
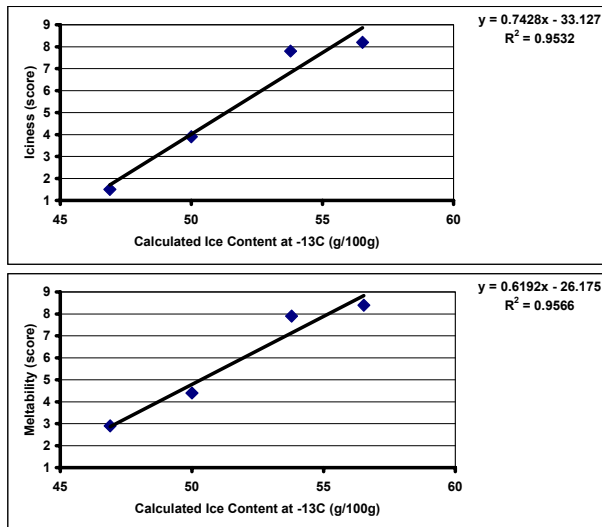


Figure 3. Comparison of Sensory Analysis Scores for Mouthfeel with TechWizard™ Calculated Values for Ice Creams with Varying Fat Content.



Sensory scores for appearance, icy mouthfeel, and meltability of the ice cream obtained using descriptive analysis correlated nicely ($R^2 > 0.95$) with the estimated values for percent product frozen (g ice / 100 g product at serving temperature, -13°C). Furthermore, the estimates of sweetness intensity of the ice cream samples obtained using the TechWizard™ were very similar to the observed sweetness scores (Figure 2).

The TechWizard™ proved to be extremely effective for estimating the sensory response of the ice cream samples with varying fat content. These results demonstrate that the TechWizard™ can be an extremely useful tool for developing and screening ice creams formulations for particular consumer responses to sweetness, texture, and mouthfeel.

The next experiment considers ice cream formulations which have little if any fat and high concentrations of a variety of fat substitutes.

Experiment 2: Develop specific fat-free and low-fat ice cream formulas that have:

- Similar freezing points (varying less than 0.35 C)
- Constant calculated relative sweetness
- Varying fat-substitute compositions

Ice cream mixes ($\leq 0.5\%$ milk fat) were formulated using the dry ingredients maltodextrin (MD), milk protein concentrate (MPC), and polydextrose (PD) to maintain the same sweetness intensity and freezing points as 10% fat ice cream. Lactose reduced freeze-concentrated skim milk (LRCS) was used to formulate a 1.6% fat ice cream mix.

Table 2. Ice cream mix formulations made with fat substitutes.

Ingredient	None	(%)			
		MD ¹	MPC	PD	LRCS
Corn syrup solids, 36 DE	4.50	1.04	2.40	...	...
Sugar	13.05	13.05	13.05	10.19	...
Vanilla	0.10	0.10	0.10	0.10	0.10
Aspartame, 97%	...	...	...	0.03	0.05
Stabilizer	0.20 ²	0.20 ²	0.70 ³	0.20 ³	0.20 ²
Skim milk	78.13	67.24	68.21	67.76	30.15
NDM	4.12	5.14	5.14	5.41	11.00
Maltodextrin, 10 DE	...	13.33	6.00	5.30	6.50
Milk Protein Conc., 65% protein	...	...	4.60	...	...
Polydextrose	...	...	...	10.12	...
Lact. Reduced Conc. Skim	...	...	...	...	52.00
Sucrose equivalents, ² %	22.2	22.3	22.8	22.4	19.0
Calculated sweetness, ³	16.0	15.9	15.9	15.9	15.8
Milk SNF, %	11.0	11.0	15.4	11.4	23.6
Total fat, %	0.1	0.1	0.4	0.1	1.6
Milk solids, %	11.1	11.1	15.5	11.5	25.2
Total solids, %	28.7	38.0	37.2	36.6	31.7
Freezing point, °C	-2.29	-2.65	-2.84	-2.62	-2.52
Product frozen (-13°C), ⁴ %	56.5	47.2	46.9	48.4	53.5

¹MD = maltodextrin, MPC = milk protein concentrate, PD = polydextrose, LRCS = lactose reduced freeze-concentrated skim milk. ²The equivalent concentration of sucrose that would cause the same freezing point depression as the sugars, and milk sugars in this mix (7). ³Sweetness relative to sucrose. ⁴Corresponds to temperature at which samples were tempered.

Figure 4. Comparison of Sensory Analysis Scores for Appearance and Sweetness with TechWizard™ Calculated Values for Ice Creams Made with Fat Substitutes.

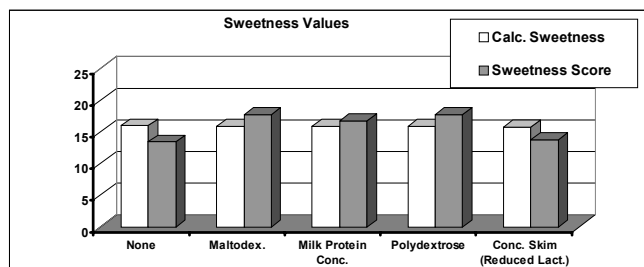
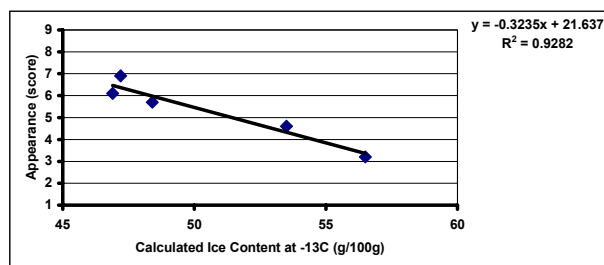
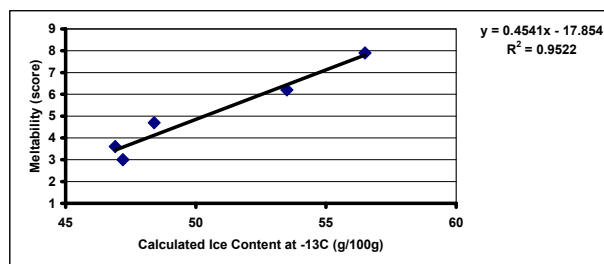
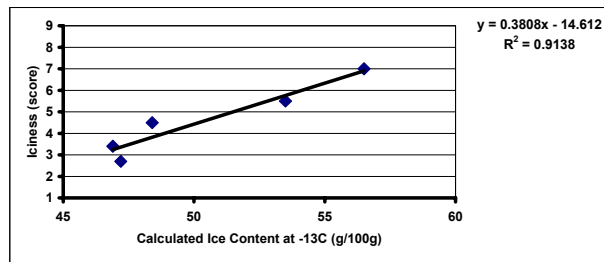


Figure 5. Comparison of Sensory Analysis Scores for Mouthfeel with TechWizard™ Calculated Values for Ice Creams Made with Fat Substitutes.



In experiment 2, there was a high degree of correlation ($R^2 > 0.91$) between sensory scores for appearance, icy mouthfeel, and meltability of the ice cream obtained using descriptive analysis and estimated values for percent product frozen (g ice / 100 g product at serving temperature, -13°C) (Figure 4 and 5).

The TechWizard™ program was designed to optimize a formulation based on goals that the user sets. In experiment 1 and 2 for example, goals were set for sweetness intensity, freezing point, fat content, total solids, milk solids not fat, vanilla, and fat substitute content. A variety of outputs were provided by the TechWizard™ including how successful the formulation process was, and compositional information as well as a best fit, least cost formulation. The calculated sweetness intensity and estimated ice content have proven to be very effective for estimating sensory response to a particular frozen dessert formulation. Currently, Owl Software is considering similar types of relationships that can be calculated and optimized for other food products.

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