SENSORY TEXTURAL ATTRIBUTES OF A FRUIT-FILLED MICROWAVEABLE WAFFLE PRODUCT

by

SHERRY A. STAM FREY

B.S., Louisiana State University, 1992

A THESIS

submitted in partial fulfillment of the
requirements for the degree

MASTER OF SCIENCE

Food Science Graduate Program

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1998

Approved by: F. M. Aramouni

Fadi Aramouni, Ph.D.
Major Professor
Dept. of Animal Sciences & Industry

LD2668
.T4
ANSC
1998
S73

ABSTRACT

Lowfat, frozen, microwaveable, on-the-go, fruit-filled Belgian waffles (*Waf-Fills*) were evaluated by trained panelists for crispness, toughness, surface roughness, scorching, color evenness, and color lightness. Five treatments of microwave powers and heating times were compared. Significant differences were observed for degree of scorching, surface roughness, and crispness with attributes more affected by time than power. Overall appearance, flavor, texture, and product acceptability (n = 51) of strawberry flavored breakfast products were significantly higher for Toaster Strudels than *Waf-Fills*, Eggos, and Pop-Tarts. Few consumers perceived waffles as snacks. A majority indicated preference for lowfat products, but only a third changed their overall product preference on that basis.

5 Key Words: waffle texture microwave lowfat sensory

TABLE OF CONTENTS

Table of Contents	i
A Photograph of *Waf-Fills*	iii
List of Figures	iv
List of Tables	v
Appendix List of Tables	vi
Acknowledgments	viii
Introduction	1
Chapter 1: Review of Literature	3
Market Trends	3
Sources for New Product Ideas	4
Frozen Food Statistics	4
Waffle Trends	5
Market Survey and Sales Figures	6
Importance of Texture Attributes	12
Consumer Attitudes	12
Crispness	13
Textural Contrasts	15
Microwave Cooking	16
Background	16
Methods of Heat Transfer	16
Factors Affecting Microwave Heating	17
Microwave Oven Components and Operation	21
Microwave Susceptor Sleeves	22
Chapter 2: Sensory Textural Attributes of a Fruit-Filled Microwaveable Waffle Product	24
Introduction	24
Materials and Methods	27
Susceptor Sleeves for Reheating	27
Preliminary Testing	27

Waffle Materials 28
Batter Ingredients 28
Filling Ingredients 29
Sample Preparation Methods 31
Filling 31
Batter 35
Waf-Fill Assembly 37
Plain Waffles 38
Descriptive Panel 41
Recruitment and Training 41
Test Conditions 42
Reference Preparation 42
Descriptive Procedures 46
Descriptive Experimental Design and Analyses 50
Consumer Panel 51
Testing 51
Consumer Experimental Design and Analyses 54
Results 56
Descriptive 56
Consumer 66
Testing 66
Questionnaire 69
Follow-up Call 74
Discussion 77
Conclusion 81
Recommendations 83
References 85
Appendix 89

A photograph of *Waf-Fills*

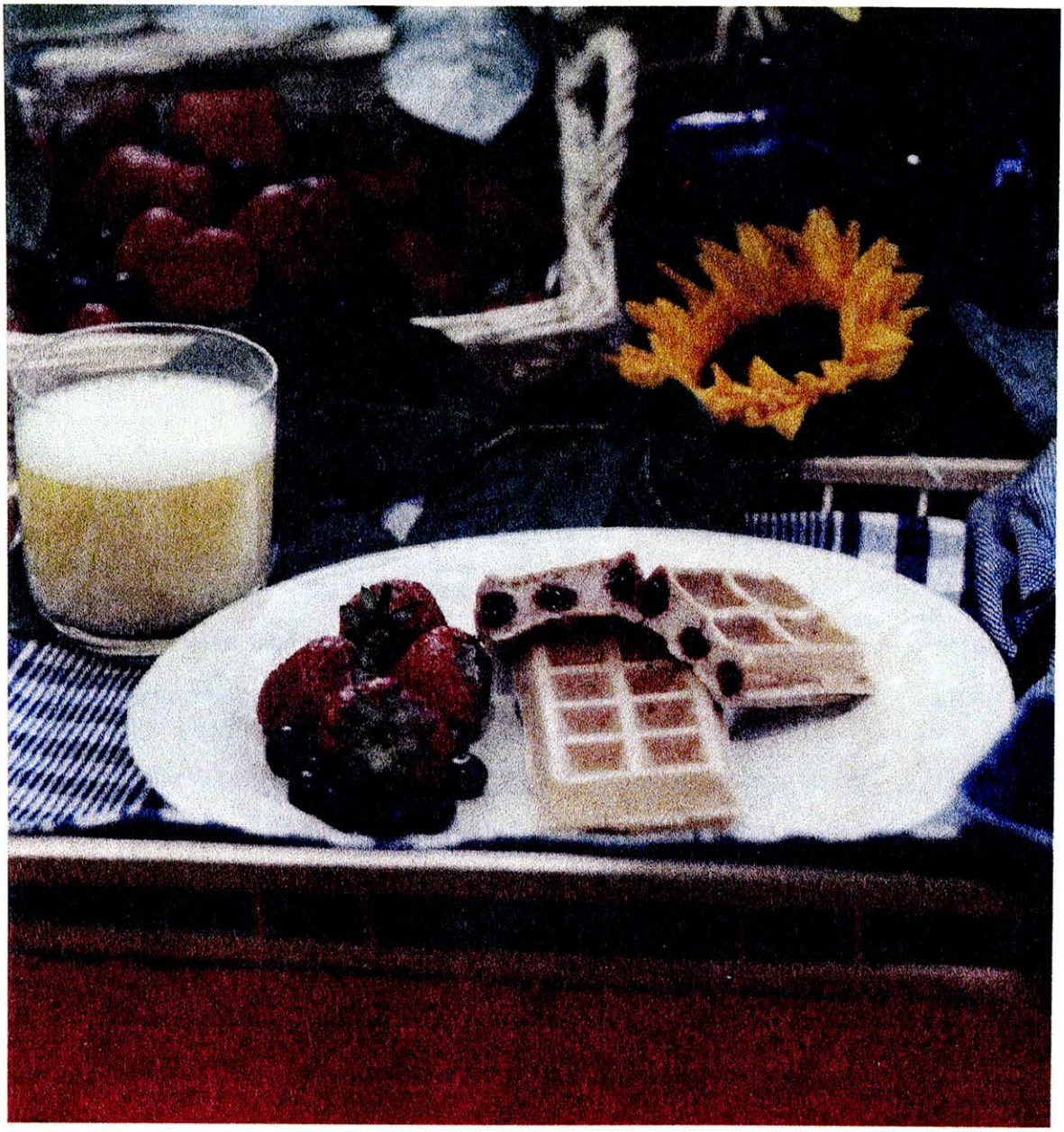


Photo by: KSU Photo Services

LIST OF FIGURES

		Page
Figure 1	*Waf-Fill* Diagram (descriptive analysis evaluation)	49
Figure 2	Descriptive panel texture attribute scores of *Waf-Fills*	61
Figure 3	Descriptive panel appearance and flavor attribute scores of *Waf-Fills*	62
Figure 4	Consumers who perceived breakfast products tested as snack products	70
Figure 5	Consumers favoring low fat products with knowledge of fat content	75
Figure 6	Influence of heating method on overall product preference	76

LIST OF TABLES

	Page
Table 1 - Reported frozen breakfast food dollar sales from January 1995 to January 1998	7
Table 2 - Reported frozen breakfast food unit sales from January 1995 to January 1998	8
Table 3 - Reported frozen waffle dollar sales for major brands from January 1995 to January 1998	9
Table 4 - Reported frozen waffle unit sales for major brands from January 1995 to January 1998	10
Table 5 - *Waf-Fill* Formulation	30
Table 6 - Rolled leather preparation procedure for *Waf-Fill* fruit filling	33
Table 7 - Fruit filling preparation procedure for *Waf-Fills*	34
Table 8 - Batter preparation procedure for *Waf-Fills*	36
Table 9 - *Waf-Fill* preparation procedure	39
Table 10 - Plain waffle preparation procedure (Modifications to *Waf-Fill* procedure)	40
Table 11 - Colorimeter results for scorched flavor references	45
Table 12 - Microwave power output measurements for the 3 microwaves used during testing	47
Table 13 - Summary of reheating procedures for products used in consumer testing	53
Table 14 - Mean appearance scores of *Waf-Fills* for varied reheat methods by the descriptive panel	57
Table 15 - Textural attribute mean scores of the *Waf-Fill's* dark corners by the descriptive panel using varied reheat methods	58
Table 16 - Textural attribute mean scores of the *Waf-Fill's* light centers by the descriptive panel using varied reheat methods	59
Table 17 - Total number of scorched flavor observations for *Waf-Fills* by the descriptive panel	60
Table 18 - Mean acceptability scores by the consumer panel for strawberry flavored on-the-go breakfast products (*Waf-Fills*, Eggos, Pop-Tarts, and Toaster Strudels)	68
Table 19 - Percentage consumers whose consumption would be influenced by fat content	71
Table 20 - Influence of heating method on consumer preference for on-the-go breakfast products	72

APPENDIX LIST OF TABLES

		Page
Table A-I	Supplier Information	89
Table A-II	References used by descriptive panelists for evaluations of *Waf-Fills*	92
Form A-III	*Waf-Fill* descriptive evaluation techniques and definitions	93
Form A-IV	*Waf-Fill* Ballot	97
Table A-V	International Electrotechnical Commission (IEC) 705, 3rd edition Test Procedure for Power Output (Summarized)	98
Table A-VI	Two-Liter Test for Determining Microwave Power	99
Table A-VII	One-Cup Test For Distinguishing Between High and Low Power Microwaves for Use by Consumers	100
Table A-VIII	Analysis of Variance results for appearance attributes of *Waf-Fills* reheated in a microwave at 650 watts for 60 s, 650 watts for 75 s, 1000 watts for 50 s, 1000 w for 60 s, and 1000 watts with sensor	101
Table A-IX	Analysis of Variance results for dark corner textural attributes of *Waf-Fills* reheated in a microwave at 650 watts for 60 s, 650 watts for 75 s, 1000 watts for 50 s, 1000 w for 60 s, and 1000 watts with sensor	102
Table A-X	Analysis of Variance results for light center textural attributes of *Waf-Fills* reheated in a microwave at 650 watts for 60 s, 650 watts for 75 s, 1000 watts for 50 s, 1000 w for 60 s, and 1000 watts with sensor	103
Table A-XI	Probabilities from Least Squares Means tests comparing effects across dark corner and light center portions of the *Waf-Fill* by the descriptive panel	104
Form A-XII	Prescreener used for consumer testing	105
Form A-XIII	Informed consent form used by consumers	107
Form A-XIV	Ballot used for consumer test	108
Form A-XV	Post evaluation questionnaire given to consumers	109
Form A-XVI	Follow-up questionnaire used with selected consumers	110
Table A-XVII	Presentation order used for consumer acceptability testing of four products	111

		Page
Table A-XVIII	Consumer panel Analysis of Variance results for panelist and treatment effects	112
Table A-XIX	Probabilities from Analysis of Variance results for acceptability of KSU *Waf-Fills*, Kellogg's Eggo Waffle, Kellogg's Pop Tart, and Pillsbury Toaster Strudel	113
Figure A-XX	Consumer panel acceptability scores for KSU Waf-Fills with strawberry filling, Pillsbury Toaster Strudel with strawberry filling, Kellogg's Eggo waffle with strawberry pieces, and Kellogg's Pop-Tarts with strawberry filling.	114
Table A-XXI	Initial consumer acceptability testing of *Waf-Fills*a	115
Figure A-XXII	Susceptor sleeve diagram (unfolded)	116

ACKNOWLEDGMENTS

I would like to extend my sincere appreciation for the guidance and support given by my committee members Dr. Fadi Aramouni, Dr. Carole Setser, and Dr. Tom Herald. My gratitude is also extended to all of my professors and the 1996-97 IFT Product Development Team for the challenges presented before me and the confidence gained after meeting those challenges. To my advisor, Dr. Aramouni, I am eternally grateful for the learning opportunities he afforded for my future success as a food scientist. In addition I would also like to thank my baking science professor, Marvyn Willyard, for sharing his vast industrial experience with the academic community. His insight was invaluable.

This research could not have been possible without the enthusiasm, patience, and devotion of my descriptive panelists. I am also thankful for the help by many fellow graduate students, especially Stefan Bucher, Khalid Khatib, and Hossein Mansoubi who were always willing to assist me, regardless of the task. Thanks to Todd Renn for his assistance with the statistical programming.

My success as a graduate student was reflective of the love, support, and ultimate sacrifice by my husband, Mark. I could never thank him enough for understanding the importance of this accomplishment. Thanks also goes to our family, who never doubted my ability to succeed at whatever I pursue.

INTRODUCTION

With the increasingly busy lifestyles of today's consumers, products that deliver convenience along with quality and indulgence are profitable. Market trends in the late 1990's include reduced fat or reduced calories, fruit additives, multiple textures, different shapes and sizes, ethnic (regional) flavors, wraps, and convenience foods with prepackaged single servings (Classon, 1996; Neff, 1996; Stewart, 1996; Robinson, 1997a; O'Donnell, 1997).

Waf-Fills were developed in response to current trends (1996-97 Kansas State University Institute of Food Technologists Product Development Team). *Waf-Fills* are a frozen, pre-baked, microwaveable, low fat, gourmet Belgian waffle bar with three tunnels of tart, strawberry filling. Waffles, according to Webster, are a "light, crisp batter cake baked in a waffle iron that is indented to impress a grid pattern into the batter as it bakes." Six *Waf-Fill* bars are individually prepackaged along with microwave susceptor sleeves (used for crisping) in a reclosable paperboard box. Multiple textures of a warm, smooth, filling with real fruit pieces enclosed in a crispy outer waffle characterized this product. *Waf-Fills* were targeted as a convenient, indulgent breakfast food or snack item that could be prepared in less than five minutes for people on-the-run such as students, professionals, middle income singles, and families. Primary consumers would be 15-45 years of age.

Initial consumer testing was conducted during the spring of 1997. Consumers, n = 58, representing a general population found at a university, were tested without being prescreened as waffle consumers. *Waf-Fills* were assessed using a nine point hedonic scale anchored at both ends (1 = dislike extremely and 9 = like extremely). The results, summarized in Appendix Table A-XXI, suggested improvement of the waffle texture was necessary, because 48% of respondents assigned a score of six or less to this attribute. Comments suggested the product should be crispier or crunchier. Scorching of corners was also observed on numerous occasions.

The purpose of this research was to improve the waffle texture by increasing crispness and reduce the degree of scorching observed after microwaving the *Waf-Fill* in two high powered (650 and 1000 watts) microwave ovens. Changes were performed using a customized susceptor sleeve (James River Corp., Milford, OH) and evaluated by descriptive sensory analysis. A descriptive panel evaluated appearance (degree of scorching, color evenness, and color lightness), texture (dark corner - toughness, surface roughness, crispness and light center - toughness, crispness), and flavor (scorched) following five different microwaveable reheat combinations (650 watt for 60 s, 650 watt for 75 s, 1000 watt for 50 s, 1000 watt for 60 s, and 1000 watt sensor function for 75 s). During the Spring of 1998, consumers, n = 51, measured the acceptability of the optimized *Waf-Fill* (1000 watts/ 50 s reheat) and three potential competitive products (Kellogg's Eggo waffle with strawberry pieces, Kellogg's Pop-Tart Toaster Pastry with strawberry filling, and Pillsbury's Toaster Strudel with strawberry filling). Consumers were also asked to provide attitude information regarding how their consumption was influenced by fat content and heating methods (toaster versus microwave oven) as well as identify their overall favorite product of those tested.

These competitive products were chosen for several reasons. All products are marketed for convenience, so they can be heated quickly and eaten on-the-go. The products contain either a strawberry filling or pieces and can be compared based on a fruit additive, even though the fillings/ pieces are quite different among the products. The frozen products compete with each other in the supermarket. Kellogg's Eggo waffle is the number one selling frozen waffle. Kellogg's Pop-Tart was tested because this market is continuously growing because of its convenience. Reported sales for all toaster pastries were $479.9 million in 1995 and rose to $532.6 million in 1996 (about 10% increase) (Gorton, 1997). Reported frozen waffle sales were $528.3 million in 1995 and $533.2 million in 1996 (about 1% increase) (Robinson, 1997c).

Chapter 1: REVIEW OF LITERATURE

Market Trends

Products that provide "better-for-you" qualities (providing less guilt), convenience, optimal sensory characteristics including textural blending, natural freshness, and allow one to indulge have increased in demand over the past few years (Neff, 1996; Stewart, 1996; Posten, 1996 and 1997; Dornblaster, 1997; Postlewaite, 1997a; Kohn, 1998). Of all new product introductions in 1996, two thirds of the manufacturers introduced gourmet or premium products (Postlewaite, 1997a). Overall new product introductions decreased 7% from 13,266 in 1996 to 12,398 in 1997. For reduced and low fat nutritional claims, a 32% decrease in new product introductions from 2,076 in 1996 to 1,405 in 1997 was reported; however "better-for-you" products are still desirable (Staff, 1998a; Dornblaster, 1998a). For new products introduced in 1997, outstanding trends included products that were eaten on-the-go, targeted towards ethnic consumers, home meal replacements, kid oriented foods, and flavors described as hot, spicy, or strong (Staff, 1998a). No one accepted definition exists for on-the-go products, but they are most commonly described as products that one can grab and eat on the way out with minimum preparation and do not require consumption while sitting at a table.

Consumers are continually enticed to purchase convenience and quick preparation products. Women make the primary purchasing decisions in many households. Charlet (1997) reported that 75% of women buy and use some type of convenience food. Dwyer (1997) reported that 80% of meals currently take 30 minutes or less to prepare while the fastest growing meal category takes less than 5 minutes to prepare.

Today's consumers not only desire quality, but wish to explore new exciting flavors and will pay a premium price for such indulgence. These pleasurable products

offer experiences, such as stimulating appearances, enticing aromas or textures after minimal heating, and multiple textures (Posten, 1997).

Sources for New Product Ideas

Restaurant food type or flavor trends are good indicators for potentially successful product ideas, for example fruit salsas, risotto, stir-fry, and wraps. According to a recent Research & Development Investment survey of food company professionals, respondents indicated multiple sources for new product ideas. Some respondents indicated more than one source. Results were as follows: 53% from ideas in restaurant menus, 64% from competitors, 62% from ideas in trade publications, 53% from suppliers, and 40% from internal company chefs. Current restaurant trends include vegetarian, red meat, Asian/ Pacific, Italian/ Mediterranean, and retro or comfort foods like meat loaf (O'Donnell, 1997).

Frozen Food Statistics

Within one week, the average consumer shops 2.5 times at the supermarket (Anonymous, 1997a). The typical frozen food purchaser is a "woman who is a youngish baby-boomer and is part of a family with kids" according to Steve Schmidt, president of A C Nielsen-US. He also stated that as income increases towards $50,000 to $59,000, the tendency to purchase frozen foods also increases (Anonymous, 1997b).

Besides supermarkets, convenience stores, mass merchandisers (ex. Wal-Mart), and drug stores have begun offering sales of frozen food items (Robinson, 1997b). As reported in early 1996, prepared frozen food sales are projected to grow 25.5% to $12.3 billion by 1999. Within this category the strongest growth over the next 5 years is expected in appetizers and pizzas and slowest growth in vegetables and side dishes, while breakfast foods would be in the middle (Anonymous, 1997c).

Retailers were asked to vote on the ten best frozen products of 1997 based on innovation and sales potential. Items selected, such as the Morningstar Farms low-fat breakfast sandwich, offered something new in convenience, health, indulgence or taste and focused on consumer needs (Thayer, 1997).

Waffle Trends

Meals and snacks of today no longer suggest distinct differences in many instances. Consumers have been described as "grazers" who snack as much as 85% more than in 1993. Snacking has increased so much for the average person that snacks are becoming a "fourth meal" accounting for about 25% of the daily caloric intake. Sales near the end of 1997 were reported to be $368.7 million, representing an increase of 11.8% from the previous year. Frozen snacks are convenient and appear to be a growing category for the future (Postlewaite, 1997b).

Currently waffles are not marketed just as a breakfast food, but can be considered a snack food since they are healthy, easy to prepare, can be eaten on-the-run, and are inexpensive (Staff, 1998b; Dornblaster, 1998a). In the waffle category, 25 new products were introduced in 1997 compared to four new products in 1996. The Belgian-style was the most popular form for these new products, which may or may not require heating. Waffle mixes were also introduced. Flavors included buttermilk and blueberry. Waffle categories emerged from these new introductions that targeted only children or only adults. Other categories included unusual flavors, "better-for-you" waffles, and Flax Plus Toaster Waffles (Dornblaser, 1998a; 1998b). These trends continue to support the potential success for the *Waf-Fill* product as a gourmet product targeted mainly for adults, with the unusual tart strawberry filling flavor enclosed in a low fat, better-for-you waffle.

Market Survey and Sales Figures

A market survey of breakfast foods, which could be prepared in five minutes or less and eaten on-the-go, was performed at a supermarket (Dillon's, Manhattan, KS) during August - September of 1996. Six major categories were identified that included fruits (fresh, canned, pureed, and dried), dairy products (yogurt, eggs, and cottage cheese), frozen convenience products (waffles, French Toast, pastries, breakfast sandwiches, breakfast pizzas, breakfast burritos, bagels, and breakfast platters), bar products (granola, cereal with filling, crisp rice, and graham), breakfast drinks (powdered and ready-to-drink), and retail and wholesale products (bagels, English muffins, crumpets, toast, waffles, muffins, coffee cakes, donuts, Danish's, etc.). Current market trends included reduced fat and/ or calories, fruit additives, multiple textures, different shapes and sizes, and convenience foods with prepackaged single servings (Classon, 1996; Neff, 1996; Stewart, 1996).

The frozen waffle competitors in this market included Kellogg's Eggo, Kellogg's Nutri-Grain, Kellogg's Special K, Kellogg's Common Sense, Pillsbury's Downeyflake, Quaker Oat's Aunt Jemima, and Food Club. Kroger had a shelf stable European style waffle. It was also observed that the competitor's frozen waffles contained 4 - 10 servings per package and prices ranged from $0.25 - 0.80 per serving.

Sales for the total frozen breakfast foods category, frozen waffle industry, and frozen breakfast foods other than waffles are summarized in Tables 1 and 2 in terms of dollar sales, unit sales, and percentage increase or decrease from January 1995 to January 1998. Dollar and unit sales are indicated in Tables 3 and 4 for Kellogg's Eggo, Downeyflake, Aunt Jemima, Pillsbury Hungry Jack, and private label companies for these same years (Robinson, 1997c; Friedman, 1998).

Table 1-Reported frozen breakfast food dollar sales from January 1995 to January 1998[c]

Category	1995 Dollar Sales[a] (in millions)	1996 Dollar Sales[a] (in millions)	1/97 to 1/98 Dollar Sales[b] (in millions)	% Change in Sales from 12/95 to 12/96[a]	% Change in Sales from 1/97 to 1/98[b]
Frozen Breakfast Foods Including Waffles	793.5	794.8	848.6	0.2	6.9
Frozen Waffles Only	528.3	533.2	574.6	0.9	7.6
Frozen Breakfast Foods other than Waffles	265.2	261.6	274.0	-1.4	5.5

[a] Dollar Sales represent 52 weeks ending 12/29/96 vs. 12/31/95

[b] Dollar Sales represent 52 weeks ending 1/4/98 vs. 1/5/97

[c] Adapted from Robinson, 1997c and Friedman, 1998

Table 2-Reported frozen breakfast food unit sales from January 1995 to January 1998[c]

Category	1995 Unit Sales[a] (in millions)	1996 Unit Sales[a] (in millions)	1/97 to 1/98 Unit Sales[b] (in millions)	% Change in Units from 12/95 to 12/96[a]	% Change in Units from 1/97 to 1/98[b]
Frozen Breakfast Foods Including Waffles	439.8	426.9	448.2	-2.9	5.1
Frozen Waffles Only	277.6	275.6	297.8	-0.7	7.9
Frozen Breakfast Foods other than Waffles	162.2	151.3	150.4	-6.7	0.1

[a] Unit Sales represent 52 weeks ending 12/29/96 vs. 12/31/95

[b] Unit Sales represent 52 weeks ending 1/4/98 vs. 1/5/97

[c] Adapted from Robinson, 1997c and Friedman, 1998

Table 3-Reported frozen waffle dollar sales for major brands from January 1995 to January 1998[c]

Company	1996 Dollar Sales[a] (in millions)	% of Total Dollar Sales for 1996[a]	% Change from 1995 to 1996[a]	1/97 to 1/98 Dollar Sales[b] (in millions)	% of Total Dollar Sales for 1997[b]	% Change in from 1/97 to 1/98[b]
Kellogg's Eggo	278.5	52	7.3	300.8	52	7.8
Downeyflake	82.0	15	-0.2	54.1	9	-35.9
Aunt Jemima	35.6	7	-2.4	45.1	8	27.1
Pillsbury Hungry Jack	NA	NA	NA	24.3	4	NA
Private Label	31.9	6	29	40.8	7	26.5

[a] Dollar Sales represent 52 weeks ending 12/29/96 vs. 12/31/95

[b] Dollar Sales represent 52 weeks ending 1/4/98 vs. 1/5/97

[c] Adapted from Robinson, 1997c and Friedman, 1998

Table 4-Reported frozen waffle unit sales for major brands from January 1995 to January 1998[c]

Company	1996 Unit Sales[a] (in millions)	% of Total Unit Sales for 1996[a]	% Change from 1995 to 1996[a]	1/97 to 1/98 Unit Sales[b] (in millions)	% of Total Unit Sales for 1997[b]	% Change in from 1/97 to 1/98[b]
Kellogg's Eggo	135.8	49	3.3	143.0	48	5.3
Downeyflake	44.6	16	-3.1	29.5	10	-35.8
Aunt Jemima	22.7	8	-1.5	31.0	10	37.0
Pillsbury Hungry Jack	NA	NA	NA	44.6	15	NA
Private Label	23.9	9	19.6	29.6	10	22.3

[a] Unit Sales represent 52 weeks ending 12/29/96 vs. 12/31/95

[b] Unit Sales represent 52 weeks ending 1/4/98 vs. 1/5/97

[c] Adapted from Robinson, 1997c and Friedman, 1998

From the dollar and unit sale figures indicated in Tables 1-4, frozen waffles represented 64.6% and 66.4% for unit sales as well as 67.1% and 67.7% dollar sales of the total frozen breakfast foods category in 1996 versus 1997, respectively. Clearly the frozen waffle category represents the largest portion of all frozen breakfast foods purchased. Moreover, waffle sales in dollars increased from 1995 to 1996 when a loss was reported in the remaining breakfast categories. While unit sales did decrease slightly from 1995, the decrease was significantly less than that reported for the remaining breakfast foods. Dollar and unit sales for frozen waffles displayed the greatest growth (7.6% versus 7.9%, respectively) when compared with the entire frozen breakfast foods category (6.9% versus 5.1%, respectively) and other frozen breakfast foods category (5.5% versus 0.1%, respectively) for 1997 (Robinson, 1997c; Friedman, 1998).

Although many breakfast food items were identified in the five minute meal category, no other filled waffle product existed. The *Waf-Fill* concept was designed to fit with current marketing trends. The product was formulated with a strawberry filling and contains 3 g of fat. The bar shape is convenient for eating on-the-go and the product is characterized by two different textures, a crispy waffle and a fruit filling with seeds. The actual dimensions of the bar are 11.2 x 5.8 x 2.3 cm (L x W x H). Each serving, one *Waf-Fill* bar, was prepackaged along with a microwave susceptor sleeve. Six bars were encased in a reclosable paperboard box with package dimensions of 24.9 x 16.5 x 7.4 cm (L x W x H).

Importance of Texture Attributes

Consumer Attitudes

Foods can be described by appearance, aroma, texture including consistency, and flavor. Texture is complex, and simple changes can affect the perception of other attributes, such as flavor and appearance. Szczesniak (1990) defined texture as "the sensory manifestation of the structure of the food and the manner in which this structure reacts to applied forces, the specific senses involved being vision, kinesthetics, and hearing".

Consumer attitudes of teenagers (13 - 18 yr) and adults (over 18 yr) toward the role texture plays in the acceptance or rejection of foods have been investigated (Szczesniak and Kahn, 1971; Szczesniak, 1972, 1990). Both groups indicated that texture was an important reason for rejecting a food, while flavor was the main reason for accepting food. Texture was noticeable if flavor was bland or if the food exhibited crunchiness or crispness. Awareness of texture also increased during unpleasant experiences, such as adherence to teeth or injury to soft tissues in the mouth. Between the two groups, attitudes were influenced differently; adults were governed by various factors, such as physiological (ease of chewing and swallowing) and psychological factors, flavor intensity, socially and culturally learned expectations, socioeconomic class, and a food's image. A person's gender and occasion at which the product was eaten could also be influential. However, physiological factors had the greatest impact on teenagers. Research conducted in the early 1970's indicated that when compared with adults, teenagers were more aware of texture (Szczesniak and Kahn, 1971; Szczesniak, 1972). By the 1990's consumers as a whole were becoming more aware of texture (Szczesniak, 1990).

Appearance provided cues to the consumer about texture. Any deviation from expectations would indicate that the product was not fresh, improperly prepared, or of poor

quality contributing to low acceptance (Szczesniak, 1972; 1990). Although consumers may initially reject more products based on appearance than texture, consumers are slightly more forgiving with slight changes in flavor than with texture (Matz, 1962).

Time of day also had an effect on acceptable textures. Tolerance to texture increased as the day progressed with a preference for "passive rather than aggressive or challenging" foods in the morning (Szczesniak, 1972). For breakfast, products that had familiar textures, lubricated the mouth, were easily swallowed and digested, and required little manipulation in the mouth were preferred (Szczesniak, 1990).

Crispness

In general, consumers associated positive connotations with crispness, crunchiness, tenderness, juiciness, and firmness, while negative connotations were associated with toughness, sogginess, crumbliness, lumpiness, wateriness, and sliminess (Szczesniak and Kahn, 1971). The most versatile single texture described by consumers was crispness, which was universally accepted and contributed a dramatic effect associated with pleasant biting sounds (Szczesniak, 1988; Vickers, 1988). Iles and Elson (1972) found that increasing acceptability of texture was highly correlated with increasing crispness.

Bourne (1975) characterized crisp and crunchy foods as "rigid... stiff structures that suddenly collapse with a brittle fracture and a rapid decay of the force after fracture,... low work required for mastication, sound effects associated with brittle fracture, ... and a structure usually comprised of cellular aggregates." Consumers defined a crisp food as "one that is firm (stiff) and snaps easily (rather than bends) when deformed emitting a crunchy/ crackly sound". According to consumers, crispness differs from crunchiness because of the "snap" (Szczesniak, 1988). Scientists describe the difference as a difference in pitch with crispness characterized as having a higher pitch or frequencies above 1.9 kHz

(Vickers, 1984; Seymour and Hamann, 1988); however crispness can be determined when auditory sensations are blocked suggesting that oral tactile sensations also play a role in its identification (Christensen and Vickers, 1981).

Crispness was divided into two categories, dry crisp (found in friable and baked goods) and wet crisp (found in fruits and vegetables). Difference between the categories is recognized in the deformation of the food. Dry crisp depends on the amount of deformation during the initial bite before breaking, whereas wet crisp depends on the force for deformation (Vickers and Bourne, 1976). Investigators determined through sensory analyses that as water activity for some dry snack food products increased, crispness intensity decreased (Katz and Labuza, 1981).

Cellular arrangements related to crispness were investigated by Szczesniak and Smith (1969) as well as Vickers and Bourne (1976). Crisp foods are cellular although all cellular foods are not crisp. It was observed that as cellular structure of strawberries disintegrated with fresh, frozen, or freeze-dried berries, crispness decreased (Vickers and Bourne, 1976).

As a "tooth-oriented" attribute, crispness was described as a stimulant to promote continued eating until one reached satiety. Crisp foods can be easily manipulated in the mouth and swallowed (Vickers and Bourne, 1976). Contrasted with softness, crispness suggested freshness, wholesomeness, strength, high quality, and excellence (Szczesniak and Kahn, 1971). Hardness and/ or toughness, in addition to having negative connotations, were found to decrease crispness (Vickers, 1988; Seymour and Hamann, 1988; Szczesniak , 1990).

Textural Contrasts

In multiphased foods textural contrasts were considered pleasurable and stimulated eating; nonetheless, too many combinations within a product were undesirable (Szczesniak and Kahn, 1984). Personal preference determined what was tolerable. Contrasts were more appreciated by adults and optimized the eating experience. Most importantly a product should retain its contrasts during storage and handling. Additionally this attribute should not converge to a single texture too quickly in the mouth. Contrasts that contribute to a messy product, adhere to teeth, or injure soft tissue in the mouth were usually rejected (Szczesniak and Kahn, 1971; 1984).

The best contrasts were those combinations that fit the product concept and were vastly different, such as crisp and smooth; however, if the contrast was too great, the product was rejected. Additionally it was important that the consumer was not surprised by certain contrasts, like a hidden hard or firm texture, because difficulty during mastication could be encountered (Szczesniak and Kahn, 1971; 1984); although surprising the consumer with a hidden soft texture could add pleasure to the eating experience.

Textural contrasts related to mealtime were also investigated. Most appealing at breakfast, but also mentioned as appealing at other mealtimes as well, were crispness with softness, creaminess, or smoothness. Moistness was also important. Soggy and chalky, sticky and rough, and brittle and gummy were not desirable during breakfast. At snack time consumers preferred attributes, such as crisp and crunchy, because these attributes require biting and chewing (Szczesniak and Kahn, 1984).

Microwave Cooking

Background

Microwave ovens, first patented in 1945 by Percy Spencer, are considered "convenient, fast reheaters" that fit well with today's lifestyles. Over 150 million microwave ovens were in use in the United States in 1997, which represented a 95% saturation level, whereas in the mid 1980's only a 40% saturation level existed. A survey conducted in 1995 by the Microwave Power Institute found that the average American household spent about 25 min preparing all meals each day. Responses indicated that 78% of adults and 54% of their spouses used the microwave oven at least twice a day. The popularity of this appliance can be further demonstrated by the fact that they are also found in 75% of the work places (Schiffmann, 1997).

Developers in the late 1980's sought to formulate products specifically for the microwave oven, although products were initially developed to be used in both conventional and microwave ovens. Developers focused on understanding the important fundamental differences in properties displayed by food when cooked or heated by each appliance. Modifications to formulations allowed for improved quality, flavor, and texture of the microwaveable product, which in turn, made these products more acceptable to consumers (Schiffmann, 1997). Quality, convenience, and cost are extremely important for microwaveable products and at least two out of three of these needs are necessary for a successful product (Hegenbart, 1992).

Methods of Heat Transfer

Heat is transferred to food through conduction, convection, radiant energy, and/ or electromagnetic or microwave energy. Conduction requires direct contact with a hot surface and is considered slow since heat is transferred molecule to molecule. Convection occurs when heat travels through a moving material such as air or water. Radiant energy

heats by transferring high frequency energy waves rapidly through space. Because radiant energy waves are unable to penetrate the food, heating occurs only at the food surface. Microwave energy is transmitted, reflected, or absorbed by the food causing heat to be generated within the product instead of being transferred from the surrounding environment to the food.

Microwave heating is radically different from heating in a conventional oven. A conventional oven heats by conduction, convection, and radiant energy. Microwave ovens heat by electromagnetic energy causing the food to heat much faster. Food absorbs microwaves, converting the energy to heat. Polar molecules, such as water, produce kinetic energy or heat when they are excited by the changing electrical field. The polar molecules are excited, because polarity is reversed millions of times per second as the molecules continually attempt to align with field (Hegenbart, 1992). Ions are influenced by the electromagnetic field and affect the penetration depth of microwaves necessary to heat the food.

Factors Affecting Microwave Heating

Dielectric properties, geometry, surface to volume ratio, density, starting temperature, and quantity affect the microwave heating performance. Other properties, such as specific heat, thermal conductivity, and evaporative cooling, also influence how the food is heated in the microwave oven (Decareau, 1992; Hegenbart, 1992).

Dielectric heating involves heat that is generated inside the product; therefore ingredients have a direct influence on the dielectric properties or how the product interacts with the microwave field. A dielectric constant (ε') determines how well the product sustains the electromagnetic field, while the loss tangent ($\tan \delta$) describes how well the field inside the food is converted to heat. Loss factor (ε'') defines how well the food absorbs the electromagnetic field. The relationship is: $\varepsilon'' = \varepsilon' \times \tan \delta$ (Schiffmann, 1993).

Considering that water has high dielectric properties, products with high moisture contents heat better in the microwave than those with low moisture contents. Salt and fat also contribute to good heating qualities (Anonymous, 1983). Both the dielectric constant and loss factor can vary with temperature and their behavior varies with the actual food. Products that increase absorption of the microwave field during heating can result in "runaway heating". This phenomenon is observed in salty foods, high solid content foods, and frozen foods (during melting) (Schiffmann, 1993). For example, as distilled water is heated, the loss tangent begins to decrease while it increases with cooked ham indicating that the water actually absorbs fewer microwaves as it warms compared with the ham at the same temperature. For microwaveable products, a high dielectric constant and high loss tangent are desirable because the product can sustain the electromagnetic field and convert more microwaves to heat (Anonymous, 1983).

Food is designed to absorb microwave energy. In terms of nonfood materials, absorption is undesirable. Though packaging materials should be transparent to microwaves, devices that shield the food, such as foil or susceptor sleeves, should be reflective (Schiffmann, 1993).

Dielectric properties directly affect the degree to which microwaves can penetrate the product (Anonymous, 1983). Penetration depth (D_p) is generally the depth where 63% of the energy is absorbed. D_p is proportionally related to the length of the microwave wavelength and square root of the dielectric constant, but inversely related to the loss factor. Foods with a high loss factor usually heat quickly near the surface, because they easily absorb the electromagnetic field. Thick foods as well as high salt concentrations in foods contribute to a smaller D_p which may cause the food to heat unevenly, and may even display "runaway heating". Reductions in the thickness or salt level of the food can increase the D_p. Frozen foods have a long D_p that shortens as the food melts. Microwaves penetrate depths less than two inches more easily (Schiffmann, 1993; 1997).

$$D_p = \frac{\lambda_o \sqrt{\varepsilon'}}{2\pi\varepsilon''} = \frac{\text{microwave energy wavelength} \sqrt{\text{dielectric constant}}}{(2\pi)(\text{loss factor})}$$

Likewise the D_p is affected by the shape of the product caused by the "focusing phenomenon" of the electromagnetic field. The most preferable shape is a sphere, followed by a cylinder, because energy can be focused towards the center of the product as microwaves penetrate from all sides. This refraction of microwaves towards the center does depend on D_p, which can lead to bursting, boil-overs, and scorching. With a low D_p, energy is absorbed at the surface, while a very high D_p allows energy to pass through the center of the product without accumulation. With increasing diameters, conduction may play a role. A donut shape eliminates the difficulty encountered in heating at the center. Overheating is especially problematic with corners and sloped sides because of the angles that microwaves can penetrate, and eventual dehydration (Decareau, 1992; Hegenbart, 1994). An edge will receive twice the heating power, while a corner will receive three times the heating power (Hegenbart, 1994). This effect can be minimized by rounding the edges and creating vertical sides (Decareau, 1992). In general, regular shapes heat more uniformly than irregular, thin, or narrow ones (Hegenbart, 1992). As the surface to volume ratio increases, the product heats more quickly. At the same time the product is also able to cool more rapidly (Decareau, 1992).

Open, porous, low density foods require less heating. Multiphased foods with different densities require a longer heating period than their homogenous counterparts (Hegenbart, 1992). As the moisture content of the food decreases, so does the density (Decareau, 1992).

Starting temperature of the food and heating time are inversely related. In frozen products, ice is transparent to microwaves, so heating occurs slowly at first. Once the ice begins to melt, the heating rate increases quite rapidly (Hegenbart, 1992). Frozen foods also undergo uneven heating as the microwaves thaw the product (Anonymous, 1983).

An ideal load size, where the oven heats most efficiently, is determined for each microwave unit. Larger quantities require more heating time, but this relationship is not proportional. As the product mass doubles, heating may be increased 60 to 70% because the increased volume reduces bouncing of the waves, which have a greater chance of being absorbed by the food (Hegenbart, 1992 and 1994).

Specific heat is related to the moisture content of the product and is described as a ratio of the thermal capacity of the product compared with water (Decareau, 1992). Oils, fats, and sugars contribute localized heating with excess heating rates caused by low specific heats. Products with high water contents are more tolerant to overheating (Schiffmann, 1997). Fat has a specific heat equivalent to 0.5, which means that it requires half the energy necessary to heat the same amount of water with a specific heat equal to 1.0 (Hegenbart, 1992).

A food's ability to transfer heat as a result of a temperature difference describes its thermal conductivity. Conduction causes the frozen food to thaw slowly while heating. Conductivity is three times greater with frozen foods than nonfrozen foods. As porosity increases, the food relies less on thermal conductivity for heating (Decareau, 1992).

An increase in vapor pressure during microwave heating causes water molecules to migrate to the surface of the product. The surrounding environment is cool causing the water to condense on the product and cool the surface. This phenomena is described as evaporative cooling. The product becomes soggy and does not develop color (Schiffmann, 1997). This effect is not observed in a conventional oven or other cooking appliances, because the surrounding environment (air, water, or oil) is warm causing water evaporation, crispness, and/ or color development (Schiffmann, 1993). Addition of modified starches and emulsifiers aid in freeze/ thaw stability as well as the tolerance to microwave heating by reducing water loss, thereby decreasing premature toughening of the

product. Emulsifiers also affect dielectric properties since they are dipolar (Schiffmann, 1997).

Microwave Oven Components and Operation

Primary components of a microwave oven are the magnetron, wave guide, cavity, and mode stirrer or carousel. The magnetron generates electromagnetic radiation with a wavelength of 12.2 cm, i.e. the "microwaves". The wave guide directs the microwave radiation from the magnetron to the cavity. Inside the cavity, where the food is placed, microwaves undergo multiple reflections from back to front, horizontally side to side, and from top to bottom. Field patterns are individualized for each microwave oven. Randomization of the electromagnetic field within the cavity, whether through a fanlike device such as a mode stirrer or through the rotation of the food within the field by a carousel (turntable), provides more uniform heating (Hegenbart, 1992 and 1994).

Heating patterns can vary with food products, line voltage, and product temperature. Even within the same model, ovens can have a unique heating pattern, which contributes to hot and cold spots. As waves pass through the same region of space, interference can occur in the oven cavity. A "hot spot" occurs where reflected microwaves are added constructively. A "cold spot" occurs when microwaves cancel each other. Size of the oven cavity limits the space available for microwaves to add constructively or destructively making hot and cold spots quite common. Although carousels should even out the overall heating by exposing the food to an even amount of hot and cold spots, it is possible, for example, that the food would rotate only through hot bands. Standing waves, where the energy "stands in place", can still occur with mode stirrers. Randomization of the field increases as cavity and mode stirrer size increase. Even though it is unclear if any ovens actually contain both carousels and mode stirrers, requiring the consumer to rotate

the food during heating can reduce some of the negative effects; unfortunately consumers generally do not prefer additional steps (Hegenbart, 1992; 1994).

Low power microwave ovens range from 500 to 600 watts while high power ovens range from 600 to 1300 watts. This definition is based on the two liter test which is described along with other tests used to measure power output in Appendices Tables A-V to A-VII (Hegenbart, 1992). Power output listed by the manufacturer can be different from the microwave's actual capabilities and should be confirmed. Affected not only by line voltage, power output from a cold start is greater. After several minutes of use power is stabilized (Decareau, 1992).

Oven cavities vary from 0.028 to 0.042 m^3 (0.5 to 1.5 ft^3). Better electric field distributions are observed among the larger oven cavities, because of their ability to sustain more nodes (Decareau, 1992).

Some ovens are equipped with humidity sensors, which are located on the cavity wall in the air exhaust system. By measuring the humidity emitted through a lithium chloride moisture sensitive substance, for example, the oven can control the power and reduce overcooking (Decareau, 1992). This is especially important in bakery products, because it is quite easy to overcook these products, which cause a toughening of the texture. The sensor eliminates the guesswork involved for the consumer.

Microwave Susceptor Sleeves

Susceptor sleeves were developed and patented by Percy Spencer in the late 1980's to reduce the negative effects of evaporative cooling on bakery products. The sleeve is composed of ultra-thin metallized films, usually aluminum, which are placed on polyester substrates and laminated on paperboard for support. Metal filaments are heated by microwaves creating radiant energy and is reflected back towards the product. This action localizes the radiant heat directly on the contact surface providing crispness or uniform

popping with popcorn. The film can heat to temperatures of 204°C and has found uses in a variety of microwave products such as popcorn, pizza, pie crusts, etc. (Anonymous, 1989; Schiffmann, 1997).

Conductivity of the metallized substrate determines the film's effectiveness. If the metal filaments are too thick, arcing may occur; however, if the filament is too thin, too little radiant heat will be generated (Anonymous, 1989). Film patterns are customized for the heating requirements. Using computer simulation modeling programs, optimum patterns can be determined for the product. Boil-out of the product's moisture or oil can be controlled altering the amount of energy transmitted by the substrate to the interior of the product (Rice, 1992).

Companies have developed sleeves with different features. James River Corp. (Richmond, VA) developed the Qwik Crisp® and Qwik Check®, which provide selective heating at different locations of the food through deactivation. A.D. Tech, Inc. (Taunton, MA) developed the Safety® susceptor. This product prevents overheating and scorching by specific product optimization through a film that diffuses energy away from areas that may overheat. Beckett Technologies Corp. (Mississaua, Ontario) developed the Micro-Rite® susceptor, which eliminates hot spots and heats the product more evenly, while remaining cool (Schiffmann, 1997).

Chapter 2: Sensory Textural Attributes of a Fruit-Filled Microwaveable Waffle Product

INTRODUCTION

With the busy lifestyles of today's consumers, products that can be eaten on-the-go are increasing in demand (Staff, 1998a). Although some of these products require some heating prior to consumption, consumers often have little time for any form of preparation. The fastest heating method is usually the most desirable. Microwave heating can be the solution; however product texture of some foods, such as bakery products, can be compromised during microwave heating demonstrating the challenges faced by the product developer. Maintaining crispness through the use of susceptor sleeves has proven successful (Anonymous, 1989; Schiffmann, 1997); yet undesirable textures like toughness, surface roughness, hardness of edges caused by dehydration, sogginess, and/ or scorching can develop during heating. In such cases consumer acceptance can be affected (Szczesniak and Kahn, 1971).

Studies have shown that appearance provides cues the consumer of an expected texture, and deviations contribute to loss of acceptance (Szczesniak, 1972; 1990). Consumers are also more forgiving of slight changes in flavor than of texture (Matz, 1962). Crispness is universally accepted and seems to provide a pleasurable biting sound (Szczesniak, 1988; Vickers, 1988). Iles and Elson (1972) found that acceptability of texture was highly correlated with increasing crispness. Textural contrasts also stimulate eating. The best contrasts included crisp and smooth. Although acceptability of textural contrasts can vary with meals, these combinations were also desirable for breakfast (Szczesniak and Kahn, 1971; 1984).

Dielectric properties, geometry, surface to volume ratio, density, starting temperature, quantity, specific heat, thermal conductivity, evaporative cooling, and ingredients affect the microwave heating performance (Decareau, 1992; Hegenbart, 1992).

Products that have high moisture contents, spherical or cylindrical shapes, moderate surface to volume ratios, moderate thickness and density with homogenous counterparts, nonfrozen temperatures, high specific heats similar to water, low concentrations of fat, sugar, and salt provide the best characteristics for microwave heating (Anonymous, 1983; Hegenbart, 1992; Decareau, 1992; Schiffmann, 1993; 1997).

The diversity of product shapes and ingredients does not always allow these optimal properties to be attained. A microwaveable frozen waffle product with a filling is an example of a product with diverse textures and flavors. The *Waf-Fill* is a frozen, pre-baked, microwaveable, low fat, gourmet Belgian waffle bar with three tunnels of tart strawberry filling. This product contains many edges that are susceptible to dehydration, a high surface to volume ratio, a thick shape, a cold starting temperature, nonhomogenous textures, and a filling with high sugar concentration and containing fruit pieces. Microwaves can provide a particularly harsh environment to such a product making it difficult to obtain uniform heating while sustaining acceptable textures.

Frozen waffles represented 64.6% and 66.4% for unit sales as well as 67.1% and 67.7% dollar sales of the total frozen breakfast foods category in 1996 versus 1997, respectively. Clearly the frozen waffle category represents the largest portion of all frozen breakfast foods purchased (Robinson, 1997c; Friedman, 1998). Currently waffles are no longer marketed just as a breakfast food, but can also be considered a snack food since they are healthy, easy to prepare, can be eaten on-the-run, and are inexpensive (Staff, 1998b; Dornblaster, 1998a).

The *Waf-Fill* product was developed to be reheated in a microwave oven and characterized as a crisp golden waffle encasing a warm, smooth inner filling with fruit pieces. Although initial consumer acceptability tests, $n = 58$, indicated high acceptability of the overall product (7.0 ± 0.2), waffle color (7.3 ± 0.2), filling color (7.8 ± 0.2), and filling flavor (7.3 ± 0.2), results implied that improvement of the texture was necessary

(6.5 ± 0.3). Comments suggested the product should be crispier and crunchier. Scorching of corners was also observed on numerous occasions.

The purpose of this research was to improve the waffle texture and reduce scorching observed after microwaving the *Waf-Fill* in two high powered microwave ovens. This was performed using a customized susceptor sleeve (James River Corp., Milford, OH) and descriptive sensory analysis. A descriptive panel evaluated appearance (degree of scorching, color evenness, and color lightness), texture (dark corner - toughness, surface roughness, crispness and light center - toughness, crispness), and flavor (scorched) following five different microwaveable reheat combinations (650 watt for 60 s, 650 watt for 75 s, 1000 watt for 50 s, 1000 watt for 60 s, and 1000 watt sensor function for 75 s). Consumers, n = 51, measured the acceptability of the optimized *Waf-Fill* (1000 watts/ 50 second reheat) and three potential competitive products (Kellogg's Eggo waffle with strawberry pieces, Kellogg's Pop-Tart Toaster Pastry with strawberry filling, and Pillsbury's Toaster Strudel with strawberry filling). Consumers were also asked to provide information regarding how their consumption was influenced by fat content and heating methods (toaster versus microwave oven) as well as identify their overall favorite product tested.

MATERIALS AND METHODS

This project was performed in three parts:

1) Preliminary testing using multiple microwave powers to determine optimal reheat times for appearance and textural attributes of *Waf-Fills*,
2) Analytical evaluation by a descriptive panel of treatment combinations which were selected from preliminary results, and
3) Consumer acceptance of the product with high crispness, low toughness, and low scorching based on the analytical evaluation.

Susceptor Sleeves for Reheating

Qwik Crisp® susceptor sleeves (John Rivers Corp., Milford, OH) were used in the development of the *Waf-Fill* to provide a crisp microwaveable product. The company (James River Corporation) modified the existing sleeve specifically for the *Waf-Fill* product to improve crispness and reduce scorching of the *Waf-Fill* during microwave heating. Primarily the sleeve was custom fitted to the *Waf-Fill* to provide more uniform heating across the top and bottom surfaces of the product (Appendix Fig.A-XXII). The PET (polyethylene terepthalate) film was vacuum metallized to a specific light level of metalization and laminated to the paperboard by a proprietary method. Without a food load, the sleeve attains a temperature of 204.4°C quickly. As the food load increases, the temperature rises slowly and may never actually reach 204.4°C (Brown, 1997).

Preliminary Testing

Product evaluations using the modified sleeves were performed at extremes and two reheat times (low and high) for each power level. Reasonable treatment combinations were determined by the researcher for further testing using the descriptive sensory panel. Times were determined to prevent scorching while maintaining crispness without excessive

toughness. Internal filling temperature was also measured. Data was not statistically analyzed.

Waffle Materials

The formulation for *Waf-Fills* is denoted in Table 5. The formula remained constant throughout the preparation of *Waf-Fills* for descriptive and consumer testing; however, because of the cost of natural strawberry WONF (with other natural flavors) and 10 fold pure vanilla extract flavors (Otten's Flavors Philadelphia, PA), an artificial vanillin (Mother Murphy's, Greensboro, NC) was substituted for the strawberry and pure vanilla flavors in products used during descriptive orientation sessions. This would affect flavor attributes minimally because flavor evaluation was limited to scorched flavor.

Batter Ingredients

A commercially milled, untreated, unenriched hard red winter wheat flour was supplied by Cargill (Wichita, KS) and contained 10.7% protein, 14% moisture, and 0.5% ash. Double acting baking powder consisting of monocalcium phosphate (MCP) and sodium acid pyrophosphate (SAPP) (ADM, Olathe, KS), nonfat dry milk (NFDM) (ADM, Olathe, KS), pure vanilla extract (10 fold) and natural strawberry WONF flavoring (Otten's Flavors, Philadelphia, PA) were also donated. Granulated sucrose (Food Club, Skokie, IL), salt (Morton, Chicago, IL), extra large Grade AA liquid whole eggs (Dillon's, Hutchinson, KS), and soybean vegetable oil (Crisco, Procter & Gamble, Cincinnati, OH) were purchased locally. Finely powdered sodium benzoate (a yeast and mold inhibitor) (Diversitech, Derby, KS), sodium stearoyl-2-lactate or SSL (an emulsifier and dough strengthener) (ADM, Olathe, KS), and tap water were also used.

Filling Ingredients

CstarTex 06230 modified corn starch (Cerestar, Hammond, IN), corn syrup with 42 dextrose equivalents (D.E.) (Cerestar, Hammond, IN), natural strawberry WONF flavoring, and Sunkist® dried strawberry fruit leathers rolls (Paramount Farms, Inc., Bakersfield, CA) were obtained from manufacturers. Granulated sucrose (Food Club, Skokie, IL) and frozen, whole, unsweetened strawberries (Food Club, Skokie, IL) were purchased. Finely granulated citric acid (Haarman and Reimer Corp., Elkhart, IN), liquid red cabbage color (Warner Jenkinson Co., Inc., St. Louis, MO), and deionized water were used.

All supplier information is listed in the Appendix (Table A-I). The same lots were used when possible. Variable lots included sucrose, liquid whole eggs, frozen strawberries, soybean oil, and water. Two lots of corn syrup (42 D.E.) and modified corn starch were used.

Table 5-*Waf-Fill* formulation

Batter Ingredients				Filling Ingredients			
Dry Ingredients	**% By Weight**	**Wet Ingredients**	**% By Weight**	**Inner Filling**	**% By Weight**	**Outer Filling**	**% By Weight**
Enriched Wheat Flour	31.26	Water	42.08	Modified Corn Starch	2.47	Sunkist Dried Fruit Leather	43.77
NFDM[a]	5.74	Liquid Eggs	10.57	Water	22.01		
Sucrose	3.06	Soybean Oil	4.37	Sucrose	18.97		
Baking Powder (MCP[b], SAPP[c])	1.67	Otten's Pure Vanilla Extract (10 Fold)	0.30	Corn Syrup (42 DE[e])	7.42		
Salt	0.40	Otten's Natural Strawberry Flavoring WONF	0.30	Frozen Strawberries	4.95		
Sodium Benzoate	0.10	SSL[d]	0.16	Citric Acid	0.04		
				Otten's Natural Strawberry Flavoring WONF	0.25		
				Red Cabbage Color (liquid)	0.12		
Total	**42.23**	**Total**	**57.78**	**Total**	**56.23**	**Total**	**43.77**

[a] Nonfat dry milk
[b] Monocalcium phosphate
[c] Sodium acid pyrophosphate
[d] Sodium stearoyl-2-lactate
[e] Dextrose equivalents

Sample Preparation Methods

Detailed protocols are included in Tables 6-9, for filling, batter, and *Waf-Fill* assembly.

Filling

Three batches of filling for descriptive training and two batches of filling for descriptive data collection were prepared. Each batch size was 3200 g.

Filling was heated using a medium to high heat setting on an electric range (Westinghouse, Dublin, OH) and stirred continuously to prevent scorching. During cooking, the temperature did not exceed the upper gelatinization range (80 ± 8°C) of the modified corn starch, but was maintained at 84 ± 1°C . Flavor and color were added after 8 min of cooking to reduce the loss of volatiles and maintain color stability. Additional heating for 12 min was required to evaporate water for specified Brix measures of 65 - 68. Acid level was adjusted as needed to achieve a final pH of 3.2 ± 0.1. Acid and Brix were measured on a 50 g aliquot of filling at 22 ± 2°C. Following cooking, filling was covered and stored at 5 ± 3°C.

The pH range of 3.1 to 3.3 was chosen for color, gelation, and tartness. As pH increased, the hue became bluish, starch viscosity decreased, and flavor was altered. The Brix range of 65 to 68 was based on a protocol from Cerestar ingredients for a frozen filling.

Sunkist® dried strawberry fruit leathers were measured (101 mm x 38.7 mm) and rolled around a plastic tube with an outside diameter of 8.5 mm. To prevent sticking of the leather to the tube, no stick cooking spray (Pam®, American Home Foods, Madison, NJ) was applied on the outside of the tube. Rolls were placed on Styrofoam® plates and inserted into one gallon (26.8 cm x 27.9 cm) zipped freezer storage bags (Wal-Mart®

Stores, Inc., Bentonville, AR) to seal out air and moisture. Rolls were stored frozen (-19 ± 1°C) for easier handling during the filling injection process.

Filling was allowed to return to 21 ± 1°C and stirred before injecting. A 20 cc oral medication syringe (Apex Medical Corp., Sioux Falls, SD) was used to inject 4.18 to 6.33 g (acceptable quality control limit) of filling into the frozen fruit roll. Working with batches of 10 to 15 rolls per plate, each injected fruit roll was weighed (total weight 8 ± 2 g with the majority weighing 8 ± 1 g), placed on a Styrofoam® plate, reinserted in the freezer zipper bag, and returned to the freezer for storage. Frozen storage was necessary to maintain the shape of the roll.

Table 6-Rolled leather preparation procedure for *Waf-Fill* fruit filling:

1. Remove a 21.2 g strawberry fruit leather from package and cut 3 pieces (101 mm x 38.7 mm) from the center using a razor. Holes in the leather are unacceptable.
2. Spray a precut plastic tube with a no stick spray. Repeat as needed.
3. With rough surface facing inward, roll leather around the precut plastic tube as a guide.
4. Slide tube out of roll, place on Styrofoam® plate, and chill to -18°C in freezer before injecting the filling.

Table 7-Fruit filling preparation procedure for *Waf-Fills*:

1. Prepare a starch slurry with modified corn starch and 30% of total water.
2. Puree frozen strawberries using a small food processor.
3. Add corn syrup, sugar, remaining water, citric acid, and pureed strawberries to starch slurry and stir.
4. Heat to 83 - 86°C for 8 min and stir continuously.
5. Add flavor, color, and stir. Heat for 12 min. Maintain 83 - 86°C.
6. Cool a small aliquot (50 g) to 20 - 25°C.
7. Measure the pH.
8. Measure the Brix.
9. Cool filling to 20 - 25°C.
10. Inject 4.2 - 6 g of filling into each rolled fruit leather using a 20 cc syringe and tube fixture.
    Note : 4.18 - 6.33 g is the acceptable QC limit..
11. Blast freeze filled tubes to -30°C for 30 min or freeze at -18°C for storage.
12. Store filled tubes at -19 ± 0.1°C until needed.

Batter

Dry ingredients (flour, sucrose, salt, baking powder, SSL or sodium stearoyl lactylate, NFDM or nonfat dry milk, and sodium benzoate) were weighed and evenly dispersed using a 19 L Hobart mixer (model A-200, Hobart Co., Troy, OH). Liquid ingredients (whole eggs, soybean oil, vanilla, strawberry flavoring, and tap water) were weighed in a separate bowl and added at once to the dry ingredients. The batter was mixed following the protocol in Table 8. Specific gravity as well as initial water and batter temperatures were recorded for each batch. The batter was used immediately in the preparation of *Waf-Fills*. The batter had a 25 min storage life usable before viscosity changes were noticeable because of the leavening and hydration of dry ingredients.

Table 8-Batter preparation procedure for *Waf-Fills*

1. Mix dry ingredients (flour, sucrose, salt, sodium benzoate, baking powder, SSL[a], NFDM[b]) for 30 s at speed 2 with a 19 L Hobart mixer.
2. Add whole eggs, vegetable oil, vanilla, strawberry flavor, and water (23 ± 2°C) all at once and mix for 30 s, speed 2, and scrape.
4. Mix 30 s, speed 2, and scrape.
5. Mix 15 s, speed 1, then 15 s speed 2, and scrape.
6. Record batter temperature and specific gravity (SG). Water and batter temperature should be equivalent.

$$SG = \frac{\text{Net wt (236.6 ml of batter)}}{\text{Net wt (236.6 ml of water)}}$$

[a] Sodium stearoyl lactylate
[b] Nonfat dry milk

Waf-Fill Assembly:

Four 640 watt Belgian waffle irons (model WB-957, K-mart Kitchen Basics, High Performance Appliances, Inc., Danbury, CT) were modified by the Kansas State University Physics Machine Shop to achieve the desired rectangular shape (24.9 x 16.5 x 7.4 cm) (L x W x H) of the product. The mold was modified by adding epoxy to a custom designed stainless steel divider to the iron to achieve the previously described width. The length and height of the mold were not modified. Two plain waffles or one *Waf-Fill* could be prepared within each iron. The *Waf-Fill* procedure, described in Table 9, required extra time to insert the filling.

Irons were sprayed (about 2 sec) with an even coat of WesCoat™ (Hunt-Wesson, Inc., Fullerton, CA), an odorless and colorless aerosol pan release agent, to prevent product sticking. After two batches (about 32 *Waf-Fills* or 64 plain waffles), irons required a respray. This excess oil created an oily surface with high color unevenness on the first set of *Waf-Fills* prepared after the spray. To compensate for this effect, as well as the limited batter life, an extra batch of batter was prepared for the first set of waffles that were discarded. This extra batter allowed for full use of the batch without wasting expensive ingredients, such as flavoring. Each set of product (four *Waf-Fills* or eight plain waffles) took approximately 5 min to prepare. A set of *Waf-Fills* or waffles consisted of the total product that could be prepared at the same time in four different irons. About four sets of product were prepared within the batter life. A green light on the iron indicated that the iron was properly heated. After discarding the first set of waffles, irons were allowed to reheat for approximately 3 min, while simultaneously mixing the weighed batter. Batter temperature and specific gravity (measured twice) were recorded. For each *Waf-Fill* or plain waffle, 63 ± 2 g of batter was weighed. Irons were color coded for monitoring lots.

A batch of 10 - 15 frozen filling tubes were removed from the freezer at a time. Approximately two-thirds of the 60 - 65 g of batter was poured on one mold per iron.

Three filling tubes were placed along the long troughs of batter. The remaining batter was used to cover the filling and the iron was closed. *Waf-Fills* were cooked for 3 min each. Each of four irons was assigned a timer. The waffle was removed after the timer sounded and placed on a wire rack for cooling. The iron was reclosed and reheated for about three min or the time it took for the three remaining irons to complete cooking. After the batch was prepared, *Waf-Fills* were blast frozen for 30 min at -30°C in groups of 16 waffles. *Waf-Fills* were stored frozen (-18 to -20°C) in a labeled freezer zipped one gallon size bag.

Ingredients were measured for two batches at a time if multiple batches were prepared in a single day. Dry and liquid ingredients were kept separate until just before the batter was needed. Otherwise viscosity of the batter would increase and a significant loss in carbonation would result in the batter. Previous studies indicated that the product was shelf stable in the freezer for at least 6 mo. Final product was generally prepared and stored up to 2 wk prior to usage. Filling was stored up to 3 wk prior to *Waf-Fill* preparation.

Plain Waffles:

The procedure described in Table 10 was followed for plain waffles that were used for references and orientation. Waffles were labeled and stored frozen (-19 ± 1°C) in a zipped one gallon freezer bag.

Table 9-*Waf-Fill* preparation procedure:

1. Spray iron with nonstick spray and wipe gently.
2. Preheat iron until green light comes on (approximately 5 min).
3. For first set of *Waf-Fills* measure 65 g of batter for each and add to preheated iron.
4. Close and cook for 4 min.
5. Remove waffles and discard.
6. Close iron and allow to warm until green light comes on (approximately 3 min).
7. Measure 60 - 65 g of batter for each iron. (Prepare only one *Waf-Fill* per iron.)
8. Pour about 40 g of batter in iron.
9. Gently place 3 chilled tubes of filling along troughs of batter and cover with remaining batter (about 20 g).
10. Close iron and cook for 3 min.
11. Remove *Waf-Fill* and cool on rack for 15 min.
12. Blast freeze (-30°C) for 30 min on cooling rack.
13. Place one bar and susceptor sleeve inside cellophane and oriented polypropylene bags.
14. Store frozen (-18 to - 20°C).

Table 10-Plain waffle preparation procedure (Modifications to *Waf-Fill* procedure):

1. Follow steps 1-6 for *Waf-Fill* preparation procedure.
2. Measure 2 sets of 60 - 65 g of batter and pour into each mold in the iron. Prepare two waffles per iron.
3. Close iron and cook for 2 min 15 s for reference A or 3 min for reference B.
4. Remove waffle and cool on rack for 15 min.
5. Blast freeze (-30°C) for 15 min on cooling rack.
6. Store frozen (-18 to - 20°C) in labeled, 1 gal, zipped freezer bags.

Descriptive Panel

Recruitment and Training

Panelists were recruited using newspaper ads and local contacts in Manhattan, KS and further prescreened by telephone to determine health, availability, interest, and ability to describe familiar products. Selected panelists were further tested for the ability to describe specific attributes, recognition of familiar foods, discrimination among four tastes plus astringency and five aromatics, and ability to understand ranking and scaling techniques. A mock panel and personal interviews were also conducted. In addition, panelists were selected based on availability and interest. Intensive training was conducted over 28 h in all aspects of descriptive analysis (Abbott, 1972; Civille and Szczesniak, 1973; ASTM, 1981; Bramesco and Setser, 1990; Munoz and Civille, 1992; Rutledge, 1992).

Four female and two male (ages 20 - 70) panelists, who signed an informed consent statement, were paid for participation. The panel received an additional 12 h of orientation and practice for this product using plain waffles and *Waf-Fills*. Training focused on appearance, scorched flavor, specific textural attributes, and the appropriate references (see Appendix Table A-II) and evaluation techniques for each (see Appendix Form A-III).

A control, plain waffle, was presented to the panel during orientation sessions. The control was reheated for 45 s using a 1500 watt/ 0.042 m^3 microwave (Amana Radarange, model RR-7DA, Amana, IA). Actual power output was confirmed at 750 watts (748.13 ± 4.38 watts) with a low power level according to the 2 L and consumer 1 cup microwave power tests. Use of a control and different microwave power level were performed to reduce possible biases during actual testing.

Test Conditions

Testing was done using a round table format. The room was equipped with a moderate incandescent light level and testing was performed under ambient temperatures.

Each *Waf-Fill* was individually repackaged in a zipper closure 16.51 x 8.25 cm snack bag (Ziploc®, Dow, Indianapolis, IN) and labeled with day and a coded treatment number. To ensure that the product remained frozen on the day of testing, products were placed in an ice chest between ice and ice packs with care to avoid any physical damage to the product. Products were removed one at a time for reheating.

The ballot (see Appendix Form A-IV) was used to evaluate appearance, texture, and flavor attributes. Two *Waf-Fill* diagrams for the top and bottom surfaces were provided for panelists to mark where browning and scorching occurred. A structured category scale (0 = none to 9 = high), anchored at half point intervals and labeled with reference points, was used to record all other observations. Panelists had an evaluation diagram, references, and definitions and instructions for each evaluation (see Fig. 1 and Appendices Table A-II and Form A-III).

Product was evaluated by mouth after 3, 4, and 5 min cooling periods. Average filling temperatures with standard errors, determined during preliminary work, were 72.84 ± 0.59, 67.30 ± 0.50, and 62.93 ± 0.37°C, respectively.

Reference Preparation

For appearance references, actual *Waf-Fills* (with and without filling) were stored in zipped snack bags and affixed to a foam poster board. Specific areas of interest were circled on degree of scorching and lightness references. Scores were also listed on the board for easy reference. Between sessions the appearance references were stored frozen to reduce the appearance of degradation of the product's appearance.

Panelists were presented with lightly, moderately, and darkly scorched toast for flavor references. To ensure consistency of the reference from day to day, one large batch of each degree of scorching was prepared. Three 680.4 g loaves of white sandwich bread (Dillon's, Hutchinson, KS) were purchased. Crusts were removed and slices were cut into fourths. Pieces were spread over a cookie sheet and baked in a 104.4°C oven (Whirlpool Self-Cleaning Oven, model RB160PXYB, Benton Harber, MI) for about 30 min, or until dried. Working in batches, toast was scorched within minutes on both sides at 204.4°C. Visual observations produced batches with shades of moderate browning, dark browning with areas of black, and completely blackened to represent three levels of scorching. Within a scorched level, samples were finely ground and stored in a labeled 1-gal zipper bag. References were isolated for storage. Three measures of L (lightness with white = 100 and black = 0), a (+ = red), and b (+ = yellow) for each reference were collected using a HunterLab Miniscan Colorimeter (Model MS/S-4000S, Reston, VA). Mean values with standard errors are indicated in Table 11.

Plain waffles were prepared for reference A (moderate toughness, low crispness, and moderate surface roughness) and reference B (high toughness, moderately high crispness, and high surface roughness). The top smooth surface of the waffle always faced upward. The waffle preparation procedure is listed in Table 10. One and a half hours prior to each panel session, 20 each of reference A and B were defrosted for 15 min at ambient temperature. Four ovens were preheated for 30 min (190.6°C for reference A and 204.4°C for reference B). Ten waffles were placed on each of four cookie sheets placing one sheet on the top rack in each oven. Reference A waffles were reheated for 3 min at 190.6°C, and reference B waffles were reheated for 10 min at 204.4°C. Waffles were removed and allowed to cool on a baking rack for 67 and 60 min, respectively. Cooled waffles were transferred to labeled 15.2 cm Styrofoam® plates (Satinware, Specialty Products, Northbrook, IL) and served to panelists.

Other textural references included white pan bread (Wonder, Interstate Brands Corp., Kansas City, MO) for low toughness and cereal (Crispix, Kellogg's, Battle Creek, MI) for high crispness. All bread was bought at once from the same store, precut into 0.6 cm squares (crusts removed), placed in zipped snack bags, frozen, and defrosted 2 h before each panel session. About 1.5 h prior to the session, the cereal was placed in 96 g plastic soufflé cups (Stylo, Urbana, IL) and covered with all purpose plastic film (Parade, National Brand Sales, Arlington Heights, IL).

Table 11-Colorimeter[a] results for scorched flavor references[b]

Degree of Scorching	L[c]	a[c]	b[c]
Lightly	49.21 ± 0.50	12.27 ± 0.15	8.26 ± 0.14
Moderately	37.00 ± 0.07	6.44 ± 0.06	3.35 ± 0.03
Darkly	32.95 ± 0.02	2.81 ± 0.02	1.18 ± 0.02

a Miniscan (HunterLab Model MS/S-4000S)
b White pan bread scorched in an oven
c Reported values are mean ± standard error

Descriptive Procedures

Three different microwaves were used for reheating. For orientation a 1500 watt/ 0.042 m^3 (1.5 ft^3) Amana Radarange (model RR-7DA, Amana, IA) was used to reduce treatment bias. To simulate consumer use, two different Sharp carousel ovens (Sharp, Paramus, NJ), a 650 watt/ 0.042 m^3 model R-9700 and a 1000 watt/ 0.028 m^3 (1 ft^3) sensor model R-320AK, were used during testing to represent a new and older microwave oven models. Power output was confirmed using: the IEC 705 (3rd edition) that measures maximum power output, the 2 L water test that measures average power output after oven has been in use, and the consumer 1 cup test that determines if the oven is a low or high power level. These results are listed in Table 12 and procedures are described in Appendices Tables A-V, A-VI, and A-VII, respectively.

To reheat, the product was placed in a susceptor sleeve (Fort James Corp., Milford, OH) with the sleeve's seam (point where the sleeve is glued) against the bottom of the product. The product contains a noticeably different top and bottom surface. The bottom surface is less smooth with less color uniformity. This phenomenon occurs during the original preparation and is observed on all products. Following the appropriate reheat treatment, the product was removed from the susceptor sleeve and allowed to cool on a baking rack for 45 s.

The product was oriented on a three digit labeled Styrofoam® plate with the top surface facing upward and the dark side of the *Waf-Fill* on the left side of the plate when presented to the panelist. For consensus evaluation of the appearance (degree of scorching, color evenness, and color lightness), one *Waf-Fill* was presented to the first panelist who compared the product against the appearance reference board and recorded the score. The product and appearance reference board were then passed to the next panelist. This continued until all six panelists had observed the *Waf-Fill*. The moderator then conducted a discussion and consensus scores were recorded.

Table 12-Microwave power output measurements for the 3 microwaves used during testing

Microwave	Average Maximum Power Output[a,d]	Average Power Output[b,d]	Power Level[c,d]
Amana Radarange (1500 watt/ 0.042 m^3)	NA[e]	748.13 ± 4.38	low
Sharp Carousel Sensor (1000 watt / 0.028 m^3)	843.8 ± 21.16	787.50 ± 7.83	high
Sharp Carousel (650 watt/ 0.042 m^3)	NA[e]	665.00 ± 10.10	high

[a] Measured using IEC 705 (3rd edition)
[b] Measured using the two liter water test
[c] Measured using the consumer 1 cup test
[d] Reported values are mean ± standard error
[e] This measure was not taken

Following consensus of the first coded treatment, individual evaluations were made on individual *Waf-Fills* from their respective batches for appearance (degree of scorching, color evenness, and color lightness), texture (dark corner - toughness, surface roughness, crispness and light center - toughness, crispness), and flavor (scorched). Since texture of the product was sensitive to cooling time, the product presentation was staggered so that products were evaluated by each panelist at the same specified time intervals following the reheating treatment.

Panelists determined that judging crispness of the *Waf-Fill* by initial incisor bite versus bite and chew made little difference. Panelists selected to evaluate the product by incisor bite only. This methodology had also been used by Vickers and Christenesen (1980) who concluded through their investigations that bite versus bite and chew made little difference when evaluating crispness, loudness, and firmness.

The product was presented as described for consensus evaluation along with the same code. It took about 15 s to transport the product from the preparation area to the panelist, who immediately set his/her own timer for 2 min for the appearance evaluation. By this time the product had cooled 1 min. Fig. 1 illustrates how the product was evaluated. The timer was reset for 1 min to evaluate the dark corner. The initial bite was taken after the product had cooled for 3 min. The product was assessed with the incisors entering the top surface. First the lower left corner was evaluated for toughness. Next the upper left corner was evaluated for incisor crispness followed by surface roughness within the same bite. The timer was again reset for 1 min to evaluate the light center edge for incisor crispness followed by toughness within the same bite. Scorched flavor was evaluated if observed during any of the previous bites; otherwise it was observed last by biting the most scorched area, if present.

The next panelist was presented a product when the appearance timer sounded from the previous panelist. Evaluations continued as described for all panelists; therefore for

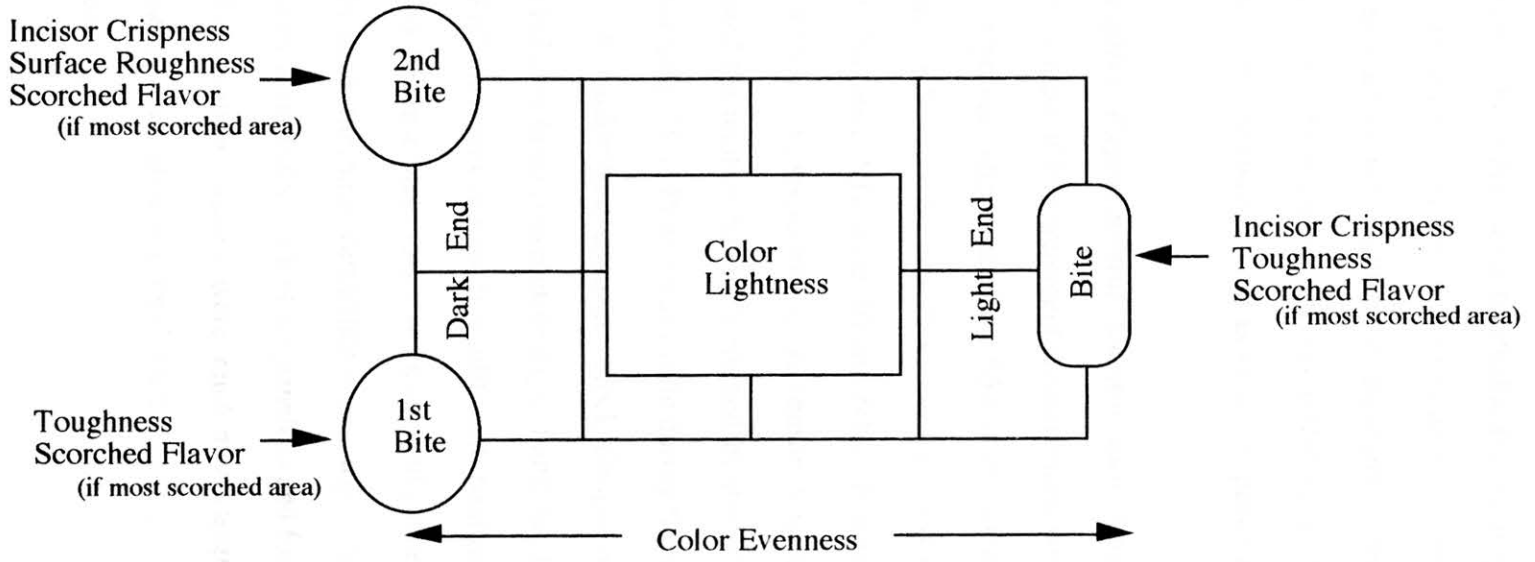


Fig. 1 - Waf-Fill Diagram illustrating how the product was evaluated during descriptive analysis.

each treatment, consensus data was first collected followed by individual responses. Panelists evaluated three treatments, had a 10 min break, and completed the remaining two treatments. Each data session lasted approximately 2.75 h.

Panelists were allowed to swallow or expectorate. There were at least 15 min between each of the treatment evaluations. Unsalted crackers and water were used for rinsing. A 0.55% carboxymethyl cellulose solution (CMC) (Aqualon, Hercules, Inc., Wilmington, DE) was offered as a rinse to panelists who were sensitive to astringency.

Descriptive Experimental Design and Analyses

A total of five treatment combinations were selected. One oven per wattage was used. Optimal reheat times for 650 watt/ 0.042 m^3 (1.5 ft^3) (model R-9700, Sharp, Paramus, NJ), were 60 and 75 s, and for 1000 watt/ 0.028 m^3 (1 ft^3) (model R-320AK, Sharp, Paramus, NJ), were 50 and 60 s. Power output was confirmed at 665.0 ± 10.1 and 787.5 ± 7.8, respectively. A sensor, within the wall of the 1000 watt microwave, measured the relative humidity emitted by the product during heating and determined the optimal time, 75 s. Power was cyclic during the sensor reheat.

A randomized complete block design was used. Descriptive panel data was collected over three consecutive days. Panelists, led by a trained moderator, evaluated nine *Waf-Fill* attributes across five different treatments each day. Waf-Fill batches were blocked, because preliminary work showed concern for batch variability. Trained panelists should have minimize variability across days. Seven batches of 16 Waf-Fills each were randomly assigned to each of six panelists and for consensus data during the testing period. *Waf-Fill*s within batches were randomly assigned to days and treatments. Order of treatment presentation was randomized. Six replications of data were collected each day by the panel.

The analysis model included seven variables (treatment, panelist, day, panelist*day, treatment*day, panelist*treatment, and residual). Day, panelist*day, treatment*day, and residual were considered random effects. Data was analyzed using the analysis of variance (ANOVA) F-test procedure of the Statistical Analysis System® (SAS Institute, Inc., version 6.12). A mixed model was analyzed using the General Linear Model (GLM) procedure of SAS.

The interaction of interest, panelist*treatment, described the consistency of the panelists' responses among treatments. If panelist*treatment was nonsignificant, then inferences were made among the treatments.

Multiple comparisons of treatments using least significant differences (LSD) to determine differences in attribute means for the five treatments were applied. The level of significance was observed at $\alpha = 0.05$.

A split plot design was used to analyze for significant differences in toughness and crispness between the light center edge and dark corner (subplots) of the *Waf-Fill* (whole plot). The model was analyzed using the Mixed Model (MIXED) procedure of SAS.

Consumer Panel

Consumer Testing

Panelists, representative of a university population, were recruited based on health, target age, and availability. Panelists, who disliked strawberry flavor, were eliminated and those who consumed minimally one of eight categories of on-the-go breakfast items at least one time/ month (see Appendix Form A-XII) were included. Panelists signed an informed consent form (see Appendix Form A-XIII) and were allowed to discontinue testing at any time.

Based on availability, panelists were randomly divided among five 30 min sessions of 12 panelists each. Sessions were conducted at the departmental sensory facilities at

8:30, 9:30, and 10:30 a.m. on day one and 9:30 and 10:30 a.m. on day two in a room equipped with 12 permanently partitioned booths. Fifty-one panelists participated.

The ballot consisted of an anchored 9-point hedonic scale (1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely) measuring overall acceptability, overall appearance, overall flavor, filling flavor, overall texture, and filling texture. Space was allocated for panelists to indicate what they liked and disliked about each product (see Appendix Form A-XIV). Each ballot was collected following each product evaluation. Four treatments (Kellogg's Eggo with strawberry pieces, Kellogg's Strawberry Pop-Tart without icing, Pillsbury's Toaster Strudel with strawberry filling, and KSU's *Waf-Fills* with strawberry filling) were assigned a randomly generated three-digit code.

Serving size consisted of one half serving for each product. Because *Waf-Fills* were developed specifically as a microwaveable product, this study focused on optimization during microwave preparation only. Toaster reheat was not investigated. Except for *Waf-Fills* that were reheated in a microwave, all products were reheated in a toaster according to package directions. One of three toasters (wide slice, four slot, model # D1051, Toastmaster®, Inc., Boonville, MO) was assigned to heat each type of product. Preparation was staggered for monadic service and evaluation. For toaster products two whole servings for each presentation order were reheated at once always using the same two slots of the toaster. Products remained in the toaster to cool slightly. Cooling times were based on package directions. *Waf-Fills* were reheated individually. Following reheating, *Waf-Fills* were removed immediately from the susceptor sleeve and allowed to cool on a baking rack. Cooling time for the *Waf-Fills* was about 3 minutes, which was the same time as used by the descriptive panel to evaluate the first bite. After slight cooling all products were halved (parallel to the width) using a knife and served at once. See Table 13 for reheating details. Products were served to be eaten on-the-go. Additional condiments,

Table 13-Summary of reheating procedures for products used in consumer testing.

Product (Code)	Reheat Method	Appliance Setting	Product Reheat Time	Cooling Time
Waf-Fill (024)	Microwave (1000 watt)	full power	50 s	2 min 45 s
Eggo (306)	Toaster (1 cycle)	between 2 and 3	1 min 43 s	30 s
Pop-Tart (228)	Toaster (1 cycle)	1	1 min	10 s
Toaster Strudel (883)	Toaster (1 cycle)	between 2 and 3	2 min 10 s	50 s

such as butter and syrup, were not supplied with the waffles; however, icing, included with the product, was applied to the Toaster Strudel after heating.

However, because of the differences in the products, internal filling temperatures varied among product types. For example the Toaster Strudel had a warm exterior pastry enclosing a cool or slightly warm filling, while the reverse was observed in the *Waf-Fill* product. Achieving the same internal temperature would have resulted in scorching of some products affecting the overall appearance evaluation. Products were reheated for the appropriate time necessary to eliminate cold spots without disturbing the appearance. Generally, warm serving temperatures among product types varied (approximately 50 - 68°F), but within product types were similar.

Panelists cleansed the palate using deionized water and unsalted crackers between evaluations. For each product, panelists were given 5 min to evaluate the product (2 min) and rest the palate (about 2 to 3 min).

Following the completed evaluation of the fourth product, consumers were given a questionnaire (see Appendix Form A-XV). Two to three days following the test, follow-up calls were made to panelists who did not select *Waf-Fills* as their overall favorite product (see Appendix Form A-XVI). Panelists were contacted if they indicated a preference for microwave reheating. Panelists, who indicated consumption preference for low fat products, were also contacted. Panelists were asked if the selection for their overall favorite product might have differed if they had had information regarding heating method and/ or fat content.

Consumer Experimental Design and Analyses

A randomized complete block design was used, where blocking was based on consumers, n=51. Tastes between panelists were expected to be variable, but consistent within panelists. Data was collected across five sessions over two days. A Latin Square

Design consisting of four balanced presentation orders for treatment testing was used (see Appendix Table A-XVII). Four treatments (products) were evaluated by each panelist for six attributes: overall acceptability, overall appearance, overall flavor, filling flavor, overall texture, and filling texture.

Data was analyzed using the analysis of variance (ANOVA) F-test procedure. The model was analyzed using the GLM procedure of SAS. Questions following completion of all product evaluations were analyzed using a Pearson Chi Square Goodness of Fit Test (cross tables) to determine if significant differences existed among age groups or between sexes within treatments. Session and presentation order effects were tested. Level of significance was observed at $\alpha = 0.05$.

RESULTS

Descriptive Results

Means, ANOVA, and least squares means results are reported in Tables 14-16, Appendices Tables A-VIII to A-X, and Appendix Table A-XI, respectively. Response data were statistically analyzed except for scorched flavor, which consisted of a zero value response for 91% of the data (Table 17).

Panelist*treatment interaction was not observed. Significant differences among treatments were observed for degree of scorching ($p < 0.01$), surface roughness ($p < 0.01$), crispness of dark corner ($p < 0.01$), and crispness of light center ($p < 0.05$). Least square means suggested a significant difference within the toughness dark corner treatment ($p = 0.0468$ for 650 watts/ 60 s and 650 watts / 75 s) (Appendix Tables A-VIII - AX).

For appearance attributes, no significant differences were reported for color evenness or color lightness (Table 14). Products were considered moderately even to even in color across all treatments (Reference E = 6, moderately even and Reference D = 8, even). All products scored slightly above reference E, suggesting color lightness was moderate (Reference E = 3.5, moderately light and Reference F = 8, dark).

Reheat times among different microwave powers can be estimated. The power level output of the first microwave oven (p_1) is multiplied by the reheat time (t_1) in that oven to estimate the reheat time (t_2) for the second microwave power level (p_2) where $p_1t_1 = p_2t_2$ (Copson, 1975; Schiffmann, 1993). Using this relationship it was determined that similar energy transfers existed between low reheat time treatments (650 watts/ 60 s and 1000 watts/ 50 s) and between high reheat time treatments (650 watts/ 75 s and 1000 watts/ 60 s). Average power output of 665 and 787 watts was used in the calculations for the 650 and 1000 watt ovens, respectively.

Significant differences among low reheat times and sensor treatments were observed for incisor crispness of the dark corner; however 650 watts/ 60 s was not

Table 14-Mean appearance scores of *Waf-Fills* for varied reheat methods by the descriptive panel

Treatments *(Power/ Reheat Time)*	Degree of Scorching	Color Evenness	Color Lightness
650 watts/ 60 s	4.72[ab]	6.89[a]	4.39[a]
650 watts/ 75 s	5.25[a]	6.69[a]	4.47[a]
1000 watts/ 50 s	4.31[b]	6.92[a]	4.44[a]
1000 watts/ 60 s	5.19[a]	6.53[a]	4.47[a]
1000 watts/ sensor	4.31[b]	6.64[a]	4.25[a]

[ab]Means within the same column with the same letter (a, b) are not significantly different ($p \geq 0.05$)

Table 15-Textural attribute mean scores of the *Waf-Fill's* dark corners by the descriptive panel using varied reheat methods

Treatments *(Power/ Reheat Time)*	Toughness[d]	Incisor Crispness	Surface Roughness
650 watts/ 60 s	5.56[b]	2.28[c]	3.97[b]
650 watts/ 75 s	6.28[a]	4.64[a]	5.97[a]
1000 watts/ 50 s	5.61[ab]	3.17[b]	4.78[b]
1000 watts/ 60 s	6.17[ab]	4.58[a]	5.83[a]
1000 watts/ sensor	5.75[ab]	3.03[bc]	4.97[ab]

[abc] Means within the same column with the same letter (a, b, c) are not significantly different ($p \geq 0.05$)

[d] Least squares means ($p = 0.0468$)

Table 16-Textural attribute mean scores of the *Waf-Fill's* light centers by the descriptive panel using varied reheat methods

Treatments *(Power/ Reheat Time)*	Toughness	Incisor Crispness
650 watts/ 60 s	5.53[a]	2.00[b]
650 watts/ 75 s	6.14[a]	4.22[a]
1000 watts/ 50 s	5.83[a]	2.33[b]
1000 watts/ 60 s	6.00[a]	3.83[a]
1000 watts/ sensor	5.94[a]	2.22[b]

[ab] Means within the same column with the same letter (a, b) are not significantly different ($p \geq 0.05$)

Table 17-Total number of scorched flavor[a] observations for *Waf-Fills* by the descriptive panel

Treatment	Total Scorched Flavor Observations
650 watts / 60 s	1
650 watts / 75 s	2
1000 watts / 50 s	0
1000 watts / 60 s	3
1000 watts / sensor	2

[a] Eight of 90 observations reported scorched flavor. Seven scored a 0.5 and one scored a 1.0 on a scale of 0 (none) to 9 (high).

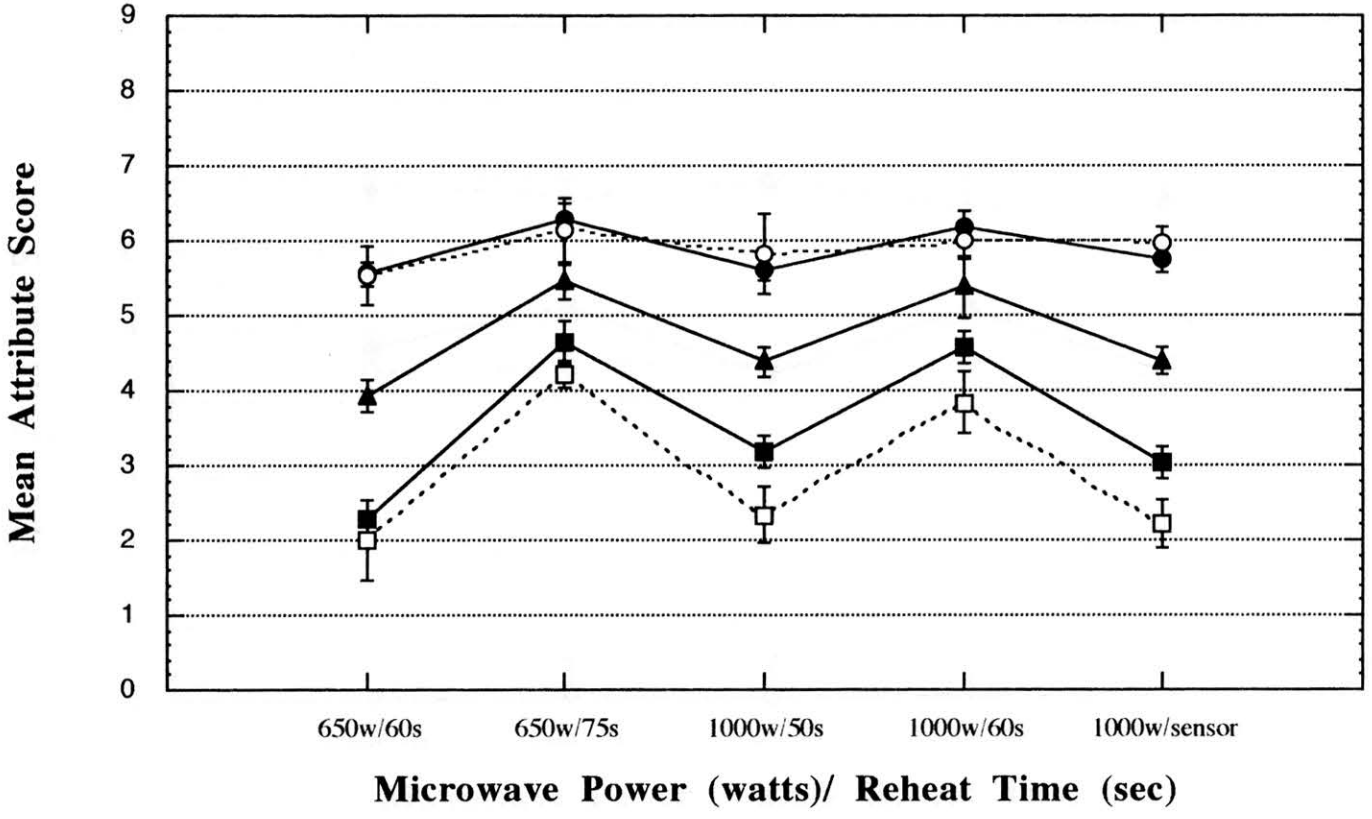


Fig. 2-Descriptive panel (n = 6) texture attribute scores of *Waf-Fills* across five treatments over three days. Texture attributes are represented by: (—●—) Toughness Dark Corner, (--○--) Toughness Light Corner, (—▲—) Surface Roughness, (—■—) Crispness Dark Corner, and (--❑--) Crispness Light Corner.

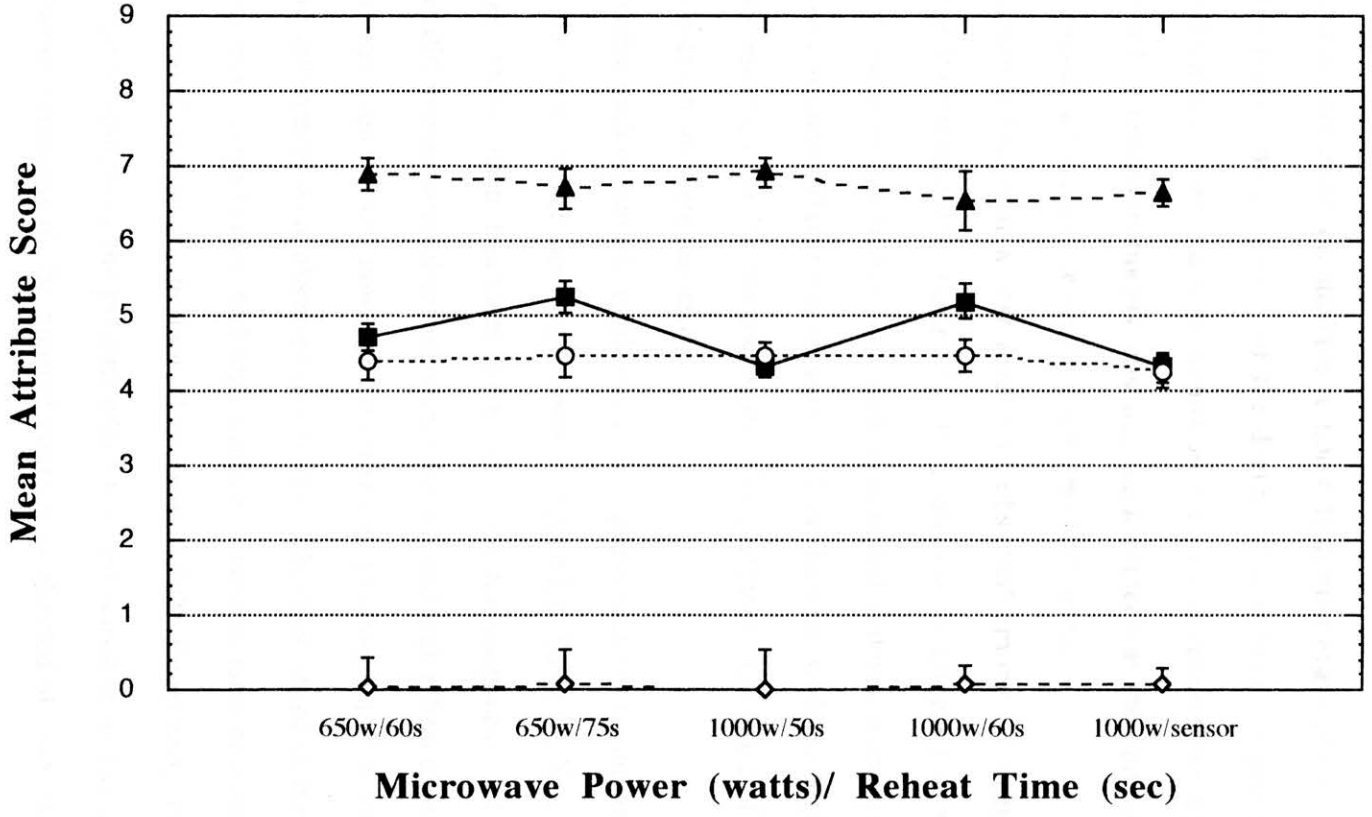


Fig. 3-Descriptive panel (n = 6) appearance and flavor attribute scores of *Waf-Fills* across five treatments over three days. Appearance attributes are represented by: (—■—) Degree of Scorching, (- -▲- -) Color Evenness, and (--○--) Color Lightness. The flavor attribute is represented by: (--◇--) Scorched Flavor.

significantly different from 1000 watts/ sensor and 1000 watts/ 50 s was not significantly different from 1000 watts/ sensor. No significant differences for any attributes tested were observed between high reheat time treatments.

The trend for eight out of nine attributes suggested that reheat time (low versus high) had a greater effect on attribute response than microwave power. Within the same microwave power, mean values for the degree of scorching, crispness, toughness dark corner, and surface roughness were significantly higher as reheat time increased (Figures 2 and 3). For low reheat treatments, crispness dark corner was the only attribute tested that showed a significant difference between 650 and 1000 watts.

Scorched flavor at a low level was observed among all treatments except for reheating at 1000 watts/ 50 s (Table 17). References were assigned scores of 1.5 and 6.0 on the 9 point scale for lightly and darkly scorched flavors, respectively. Out of 90 observations, scorched flavor was reported 9 % of the time with the highest rating of 1.0, which was reported once for the 650 watts/ 75 s treatment. On day 2 of testing, 5 out of 8 of these observations were reported.

Within each treatment, toughness and crispness data were compared for differences between the dark corner and light center (Appendix Table A-XI). No significant differences within each treatment were observed for toughness. For crispness, no significant differences were observed within the low and high reheat times for the 650 watt treatments (60 s and 75 s); however for 1000 watt treatments (50 s, 60 s, and sensor), significant differences were observed ($p < 0.01$). The thick shape of the Waf-Fill with its multiple corners, sloped sides, and high surface to volume ratio provides a challenge for attaining optimal microwave heating (Decareau, 1992; Hegenbart, 1992). This data suggests that toughness of the product edges was not sensitive to changes in power and time, although crispness of the product edges was affected at 1000 watts regardless of

reheating time. Crispness of the dark corner edge was greater than the light center edge where differences were observed.

The greatest incisor crispness for the dark corner (4.64 and 4.58, respectively in Table 15) and light center (4.22 and 3.83, respectively in Table 16) were reported for high reheat times within each power (650 watts/ 75 s and 1000 watts/ 60 s), reflecting significantly different scores from the other three treatments. Additionally these two treatments also represented the higher scores for toughness of the dark corner (6.28 and 6.17, respectively in Table 15) and light center (6.14 and 6.00, respectively in Table 16); however toughness scores for these two treatments were not significantly different from all other treatments. Surface roughness (5.97 and 5.83, respectively in Table 15) and degree of scorching (5.25 and 5.19, respectively in Table 14) for these two treatments also represented the highest scores, and they were significantly different across all treatments. In addition, light scorched flavor, as discussed earlier, was reported (Table 17).

Previous studies indicated consumers generally dislike products that irritate soft tissues in the mouth. Some textures, such as toughness and sogginess, are also disliked, but consumers generally like crispness (Szczesniak and Kahn, 1971; Szczesniak, 1990). The objective was to select the treatment with the least amount of scorching (appearance and flavor) and surface roughness along with high crispness and low toughness. For appearance the most important attribute became the degree of scorching since color lightness and evenness were not significantly different among treatments. Light scorched flavor was minimally observed. Toughness was not significantly different among treatments. Ultimately crispness and surface roughness became the most important textural attributes to consider when selecting the optimal treatment for further testing by consumers.

Panelists commented that reference B was abrasive against the palate. When comparing surface roughness scores against references (reference A = 4.5, moderate roughness and reference B = 8, high roughness), high reheat time treatments (650 watts/

75 s and 1000 watts/ 60 s) scored midway between the references (5.97 and 5.83, respectively). The remaining low reheat times and sensor treatments (650 watts / 60 s, 1000 watts/ 50 s, and 1000 watts / sensor) were more similar to reference A (3.97, 4.78, and 4.97, respectively).

Crispness was compared against references (reference A = 3.5 with low crispness, reference B = 6 with moderate crispness, and Crispix = 8 with high crispness). Low to moderate crispness was observed for high reheat times (650 watts / 75 s and 1000 watts/ 60 s) while low crispness (less than reference A) was observed for low reheat times and sensor treatments (650 watts / 60 s, 1000 watts/ 50 s, and 1000 watts/ sensor). Crispness of the product was desired as long as it could be easily observed through sound when incisors entered the product. All treatments resulted in products with noticeable sound.

Crispness was sacrificed for surface roughness, since a product perceived as scratching the palate would be more objectionable than a product that produced slightly less sound. Upon reviewing all data, 1000 watts/ 50 s was selected for consumer acceptability testing. This treatment during the descriptive testing displayed optimal appearance and texture attributes and had no scorched flavor.

Consumer Results

Testing Results

Means and ANOVA results are listed in Table 18 and Appendices Tables A-XVIII and A-XIX, respectively. Appendix figure A-XX displays consumer acceptability results for the tested products. Significant differences were observed among treatments within each attribute tested ($p < 0.01$). No session effects were observed. Presentation order effect was minimal and observed only with overall acceptability ($p < 0.05$).

Overall the Pillsbury Toaster Strudel with strawberry filling scored the highest for each attribute evaluated, ranging from 7.54 for filling flavor to 7.97 for overall flavor. Resulting scores for each attribute were significantly different from all other products tested ($p < 0.05$).

For overall acceptability, overall appearance, and overall flavor no significant differences were observed among the three remaining products.

For filling flavor and filling texture, significant differences were observed between the Eggo waffle and toaster pastry ($p < 0.05$); no significant differences were observed between *Waf-Fills* and the Eggo waffle and between *Waf-Fills* and the toaster pastry.

For overall texture, *Waf-Fills* were significantly lower ($p < 0.01$) than the Eggo waffle (5.73 vs. 6.69, respectively); however, no significant differences were observed between *Waf-Fills* and the toaster pastry and between the Eggo waffle and toaster pastry.

Product comments on the ballot indicated that consumers liked and disliked the products for different reasons. General comments by consumers for the Toaster Strudel suggested that they liked the flaky crust, icing, filling, and appearance, but they disliked the cool filling and said the product was greasy and messy. The pastry was heated as high as possible without scorching, yet the filling was cool to only slightly warm. For the Pop-Tart, consumers liked the filling and the flavor, but disliked the dry, bland crust. Some preferred toaster pastries with frosting. For the Eggo waffle, consumers liked the crispy

texture and low sweetness of the product. They disliked the plain appearance and taste, wanted more fruit pieces, and suggested that the Eggo was dry and lacked flavor. The consumers who liked the *Waf-Fill* liked the filling flavor, the warm temperature of the filling, the aroma of the product, the texture, and overall product appearance. Some suggested that the texture was rubbery, chewy, or rough and the filling was sticky, too sweet, or too large of a quantity.

Table 18-Mean acceptability scores by the consumer panel for strawberry flavored on-the-go breakfast products (*Waf-Fills*, Eggos, Pop-Tarts, and Toaster Strudels)

Treatments	Overall Acceptability	Overall Appearance	Overall Flavor	Filling Flavor	Overall Texture	Filling Texture
Frozen Belgian Waffle with Strawberry Filling (KSU's *Waf-Fills*)	6.06[a]	6.12[a]	6.24[a]	6.22[ab]	5.73[a]	6.14[ab]
Frozen Waffle with Strawberry Pieces (Kellogg's Eggo)	6.14[a]	6.33[a]	6.16[a]	5.75[b]	6.69[b]	5.91[b]
Toaster Pastry with Strawberry Filling (Kellogg's Pop-Tart)	6.49[a]	6.27[a]	6.45[a]	6.65[a]	6.41[ab]	6.59[a]
Frozen Strudel with Strawberry Filling (Pillsbury's Toaster Strudel)	7.85[b]	7.74[b]	7.97[b]	7.54[c]	7.75[c]	7.69[c]

[abc]Means within the same column with the same letter (a, b, c) are not significantly different ($p \geq 0.05$)

Questionnaire Results:

Inferences below were based on a small sample (n = 51). Because all consumers were selected at the university, the sample was not representative of a general population.

About 94% of the consumers perceived some of the products tested as snack items. Even though it was reported that waffles currently are being marketed as snack foods, less than 20% of our consumers perceived this (Staff, 1998; Dornblaster, 1998a). Consumers considered the Toaster Strudel (65%) and Pop-Tart (59%) as both breakfast and snack items. Because products can appeal differently among population segments, acceptability within each product tested was evaluated for differences based on age or sex. No differences were observed within each product. Percentages of consumers based on age or sex perceiving products tested as snack products are illustrated (Fig. 4).

The fat content per serving of the products tested was as follows: Pillsbury Toaster Strudel (9 g), Eggo waffle (8 g), Kellogg's Pop-Tart (5 g), and *Waf-Fill* (3 g). Consumers were unaware of the fat content during testing and while completing the questionnaire. Overwhelmingly 67% of consumers suggested that their consumption of the tested products would have been influenced by knowing fat content. The distribution of responses among age groups and between sexes is listed in Table 19. Of all consumers tested, 63% indicated a preference for consuming low fat products (contain 3 g or less of fat). Of these consumers, only 9% selected the *Waf-Fill*, 11% selected the Pop-Tart, 14 % selected the Eggo, and 66% selected the Toaster Strudel for the overall favorite product. It appears that many consumers say they want low fat, but actually prefer full fat products. Factors other than fat could have influenced their decisions, because the waffle and toaster pastry products were rated similarly for overall favorite rating.

Heating method would influence purchases or consumption by 65% of the consumers for on-the-go products. The distribution of responses among age groups and between sexes is listed in Table 20. These consumers equally preferred microwave and

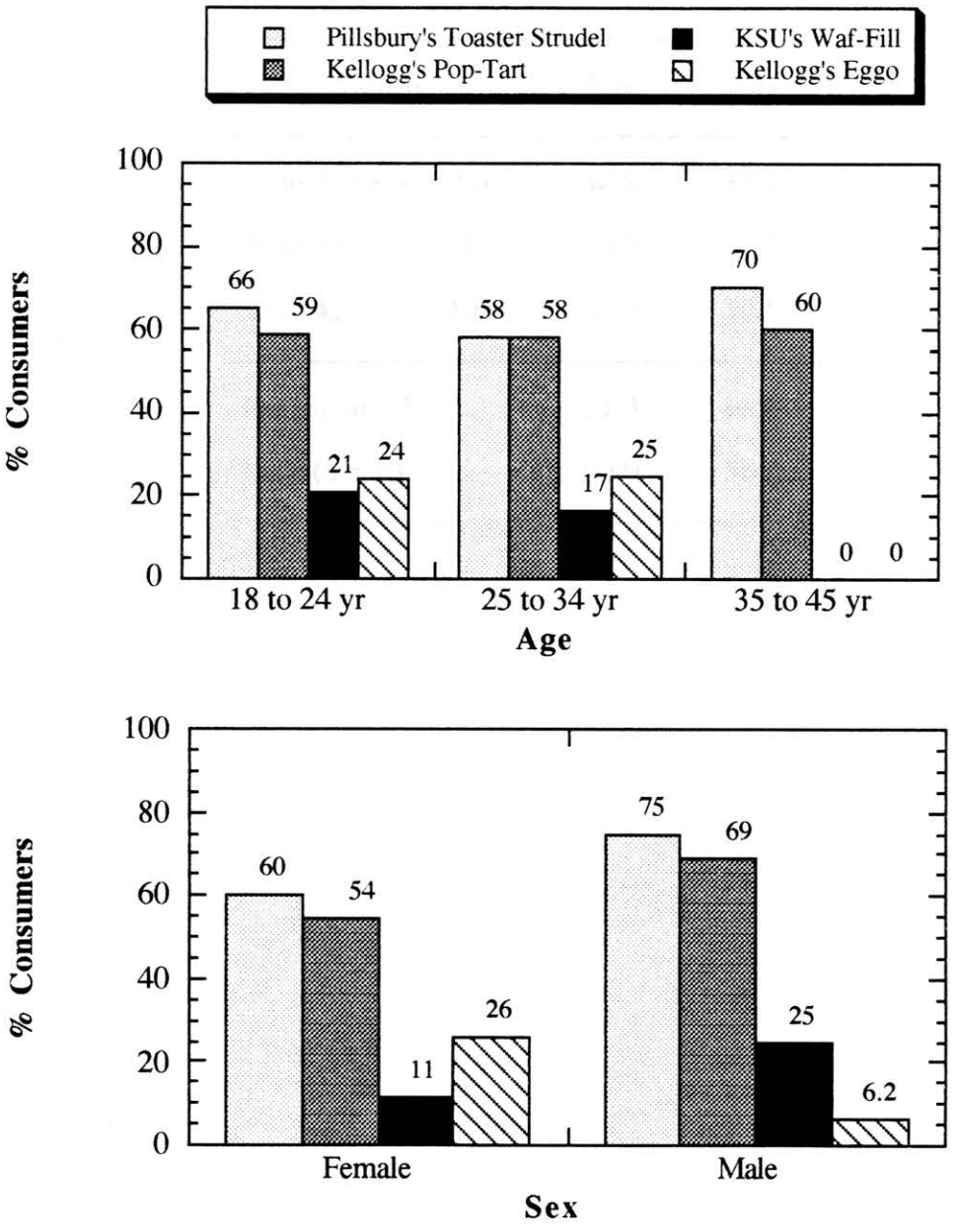


Fig. 4-Consumers who perceived breakfast products tested as snack products. Some consumers suggested more than one breakfast product as a snack. Composition was as follows: 18 to 24 yr (n = 29), 25 to 34 yr (n = 12), 35 to 45 yr (n = 10), females (n = 35) and males (n = 16).

Table 19-Percentage consumers whose consumption would be influenced by fat content

Group	No	Yes
18 to 24 yr (n = 29)	44.8	55.2
25 to 34 yr (n = 12)	33.3	66.7
35 to 45 yr (n = 10)	20.0	80.0
Female (n = 35)	31.4	68.6
Male (n = 16)	50.0	50.0

Table 20-Influence of heating method on consumer preference for on-the-go breakfast products

Group	No	Yes
18 to 24 yr (n = 29)	82.8	17.2
25 to 34 yr (n = 12)	66.7	33.3
35 to 45 yr (n = 10)	60.0	40.0
Female (n = 35)	68.6	31.4
Male (n = 16)	87.5	12.5

toaster heating methods (46% versus 54%, respectively). No other studies were found in the literature regarding preference for these heating methods.

Of the products tested, microwave instructions were available for the *Waf-Fill* and Pop-Tart. Consumers really appeared to guess when asked if product textures suggested microwave heating (45%, said no and 55%, said yes); however, twice as many consumers thought both waffle products were reheated in the microwave compared to the Pop-Tart and Toaster Strudel.

After testing all products, 69% consumers considered the Toaster Strudel as their overall favorite product regardless of any other factors, such as fat content or heating method. The remaining products were equally liked (12% Pop-Tart, 10% Eggo, and 10% *Waf-Fill*).

Follow-Up Call Results

Distributions among age groups and between sexes based on overall product preference by consumers favoring low fat products for frequent consumption (Fig. 5) and by consumers influenced by heating method (Fig. 6) are illustrated. No effects among age groups or between sexes were observed within products.

Fat content can influence frequent consumption of products by consumers. It appeared that knowledge of fat content expost facto influenced some consumers in the selection of overall favorite product. Of the 63% consumers influenced by fat content, 33% changed their decision for overall favorite product after knowing the fat level. Originally 90% of these 33% consumers selected the Toaster Strudel, but when given the fat content, 50% selected *Waf-Fills* as the favorite, 30% selected Pop-Tarts, 10% selected the Eggo, and 10% selected the Strudel.

Knowledge of heating method did not influence consumers to change the overall favorite product. Of the 46% consumers who preferred microwaving for product preparation, one changed the selection of overall favorite product from the Eggo to the Strudel.

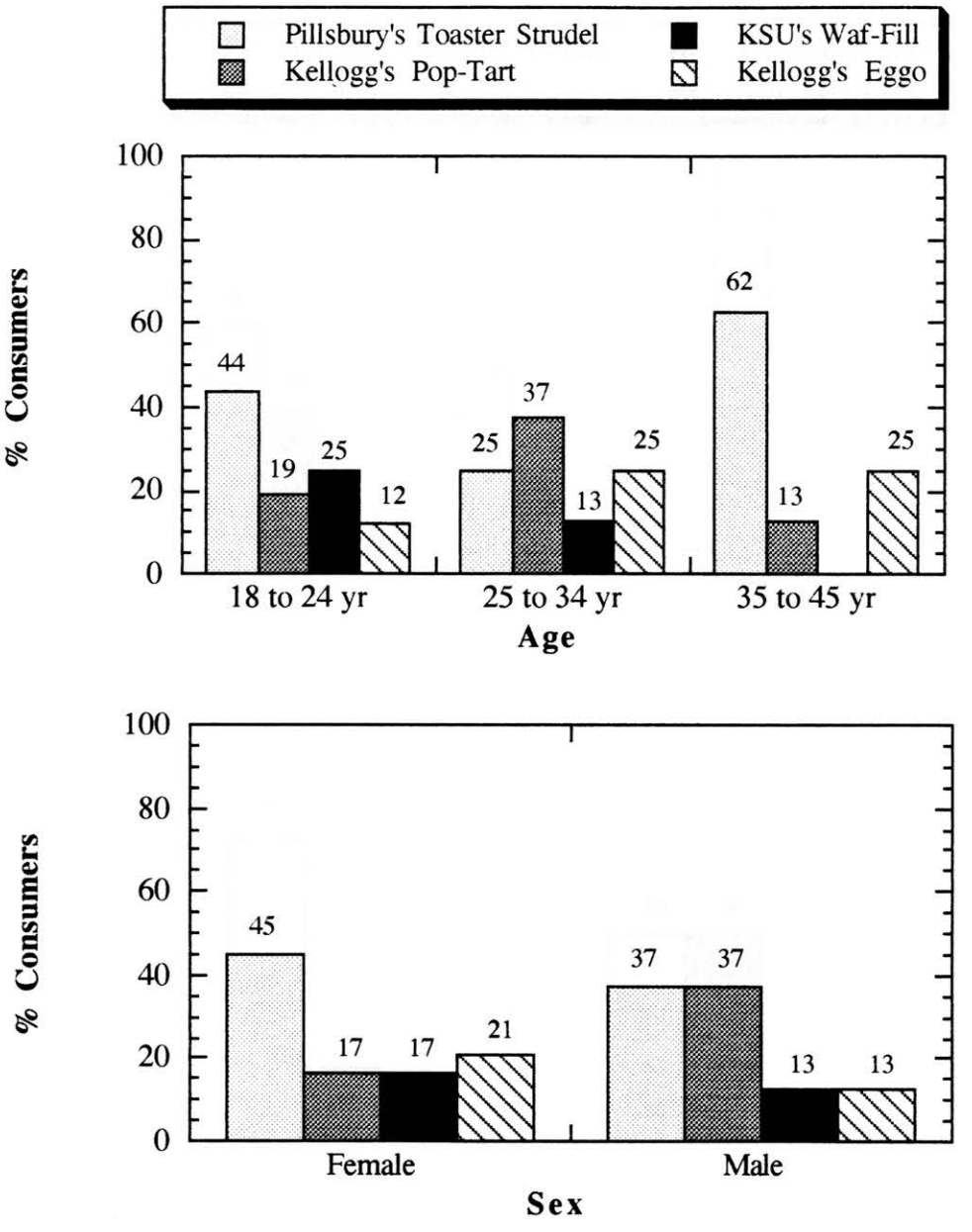


Fig. 5-Consumers favoring low fat products with knowledge of fat content. Follow-up call results are based on 63% of the consumers. Composition was as follows: 18 to 24 yr (n = 16), 25 to 34 yr (n = 8), 35 to 45 yr (n = 8), female (n = 24), and male (n = 8).

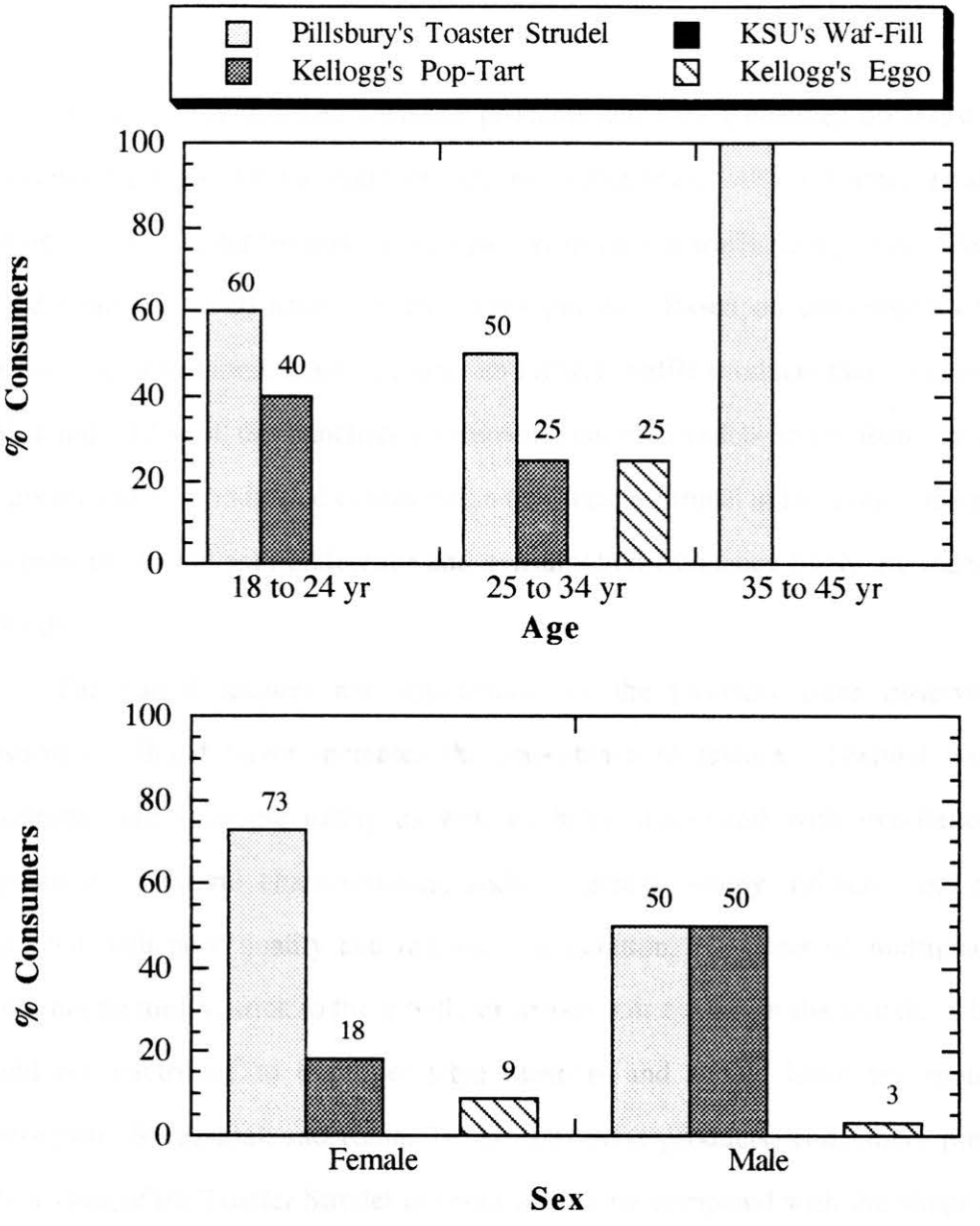


Fig. 6-Influence of heating method on overall product preference. Follow-up call results are based on 25% of the consumers. Composition was as follows: 18 to 24 yr (n = 5), 25 to 34 yr (n = 4), 35 to 45 yr (n = 4), female (n = 11), and male (n = 2).

DISCUSSION

All panelists consumed breakfast products and 98% consumed breakfast items that are eaten on-the-go. Of the eight prescreened categories, 94% consumed products in at least one of the Toaster Strudel, toaster pastry, or frozen waffle categories. Consumption ranged from 0.2 to 20 times per two week period. Based on consumption frequency, panelists consumed more toaster pastries and frozen waffle products than Toaster Strudels. In fact only 12% of the panelists consumed Toaster Strudels more than the other two categories, but 59% indicated consumption the Toaster Strudel at least one time per month. This indicates that overall preference and consumption frequency likely are independent of each other.

The varied textures and appearances of the products were observed by the consumers. Bland flavor increases the importance of texture. Textural contrasts are pleasurable and stimulate eating as well as being associated with excellence in food preparation. Textural characteristics, such as greasy, sticky, rubbery, and tough, are associated with poor quality and improper preparation. Textures of multiphased foods should not be messy, stick to the mouth, or irritate soft tissues in the mouth. The textures should not contribute to improper table manners and should leave the mouth feeling comfortable (Szczesniak and Kahn, 1971). For these products, consumers preferred the flaky texture of the Toaster Strudel covered with icing compared with the simplicity of the Eggo waffle and Pop-Tart. Many positive comments were made about the *Waf-Fill*; however texture requires further improvements. Consumers commented on crispiness more often with the Eggo waffle. Stickiness of the *Waf-Fill* filling should also be addressed, because messy products are undesirable when eaten on-the-go. Filling amount and stickiness were not optimized in this study and could have a greater affect on overall acceptability than crispness.

Important differences existed between *Waf-Fills* and the group of other products it was tested against. Factors, such as initial product preparation, reheating preparation, cooling time, method of evaluating, and fat content, must be considered. *Waf-Fills* were not commercially prepared so strict control of the process was slightly limited.

As described earlier, microwave heating can provide a harsh environment for bakery products. *Waf-Fills* was the only product prepared using a microwave. The remaining products were reheated using a toaster. Unfortunately no direct comparison against commercial microwaveable waffles were available in this market. Although the toaster pastry was the only other product that included microwave instructions, the reheat time of 3 s would provide very little time for damage to the tested attributes to occur. Additionally the differences in how crisping occurs in a toaster and microwave oven must be considered. In a toaster radiant heating of the product dehydrates the surface to provide crispness. In microwave heating, water molecules migrate to the surface and rely on the heat of the susceptor sleeve for crisping. Also quick removal of the product from the sleeve after reheating may also effect textural crisping versus softening of the product. Without a continued source of energy being supplied to the susceptor sleeve, steam could condense on the product if left in the sleeve. By removing the product from the sleeve, the steam can evaporate while cooling.

Products were cooled according to package directions. Specific times were selected so that the product was warm, but could be handled without burning the consumer during product evaluation. Toaster pastry, Eggo waffle, and strudel were cooled 10, 30, and 50 s, respectively in the toaster versus 2 min, 45 s on a baking rack for the *Waf-Fill* product. Potentially the residual heat in the toaster continued crisping the products, unlike the surrounding ambient environment of the *Waf-Fill.*

Even though the method of evaluation was strictly controlled during descriptive testing, consumers were not given specific instructions regarding how to taste the products.

Crispness by the descriptive panel was evaluated only on the edge or corner of the *Waf-Fills*; however many panelists evaluated the center of the product first. This may have affected their perception of the crispness of the product because this is indeed the least crisp area of the product as a result of the filling. A consumer's first bite would usually be an edge or corner surface, unless the product was split apart by some method. Even though the strudel had a filling and also was evaluated in the center first, a strudel is constructed quite differently from a filled waffle. Crispness of the strudel pastry is developed within multiple layers, possibly 45 to 60 layers, as a result of alternating layers of dough and fat giving the product a flaky, friable crispness. The waffle only has only one layer of crispness developed at the outer surface.

The questionnaire preference results for 63% consumers preferring low fat products were similar to the questionnaire preference results of 100% of the consumers. Fields (1996) found that frequent purchasers of low fat or no fat snack products did not apply less rigor when evaluating the taste of those products. Our results also suggest this. Though 63 % of the consumers tested indicated that they would prefer a low fat product, 91% of those respondents initially chose products other than the *Waf-Fill.* When later given the fat contents, only 33 % changed their minds. This suggests that consumers still like the textural characteristics that fat provides.

Results from the consumer testing conducted during this study (Spring, 1998) suggest that the texture is not optimal as did the results from the consumer testing conducted in the Spring of 1997. The first consumer test in 1997 was conducted to determine if the initial *Waf-Fill* prototype was acceptable; therefore prior consumers scored only *Waf-Fills.* Consumers were also aware that the product was developed at KSU, which could have influenced the evaluations. The consumers during this study (Spring 1998) were unaware of any product history; however, this test indicates that *Waf-Fills* still have textural attributes that consumers do not like, such as tough, rubbery, chewy, and

stickiness, but they are similar in overall acceptability to two other commercial products in related categories.

CONCLUSION

Product corners and edges can dehydrate during microwaving. The thick shape of the *Waf-Fill* with its multiple corners, sloped sides, and high surface to volume ratio provides a challenge for obtaining high product acceptability with microwave heating (Decareau, 1992; Hegenbart, 1992).

Limited literature was available containing methods used by a descriptive panel for evaluating waffles (Bramesco and Setser, 1990). This research identified the most important attribute characteristics of the *Waf-Fill* product and developed important evaluation techniques for a descriptive panel. These techniques could also be used for waffle products without filling as well as other bakery products that may or may not be microwaveable requiring a bite and pull action while eating.

Our data suggested that microwave heating time had a greater effect on the attributes tested than did power level. With the exception of color lightness and evenness, attribute intensity increased with time within the same power level. Among treatments tested, the degree of scorching, surface roughness, and crispness were affected by power level and/ or time. Scorched flavor was minimal. Attributes were not affected at high reheat times of 75 and 60 s for 650 and 1000 watts.

Within the product, toughness was similar between edge bites (dark corner versus light center) and was not affected differently by power level or time; however, crispness of the edges was affected differently by power level and time.

Consumers preferred the Pillsbury Toaster Strudel with strawberry filling over all products tested. Results suggest that the remaining three products were liked similarly. All products were liked for different reasons. Comments suggested the Eggo waffle was quite crisp, but bland in flavor and appearance. The *Waf-Fill's* appearance, flavor, taste, and aroma were appealing, but texture was not optimal.

Although consumers comments indicated they preferred low fat products, fats contribute greatly to the eating experience. Preference for high fat products is universal and influences the perception of appearance, taste, aroma, and texture (Drewnowski, 1997). Fat content in foods is still a concern, because a survey in 1996 reported 60% of consumers are concerned with fat content more than any other nutritional component. Another survey in 1995 reported that 70% of shoppers (versus 44% in 1992) were trying to reduce fat intake and that 74% checked the nutritional label for fat content. Surveys continue to indicate that taste outranks nutritional concerns for food acceptance (Schwartz and Borra, 1997). A study of 600 Irish mean and women concluded fat-phobic women actually reduced fat intake, while this correlation was not observed in men. Our data suggested no difference in preference for fat consumption of low fat products between women and men.

There were no real differences in preference for microwave and toaster heating methods. The most important difference was the resulting texture. With similar textures, microwaved products may be acceptable.

Although the *Waf-Fill* product has many characteristics that are not ideal for microwave cooking, the low fat product was as well liked as the two full fat competitor products (Eggo and Pop-Tart), with the exception of overall texture. Ultimately consumers will accept products based on appearance, flavor, and texture.

In summary, this study revealed that microwave reheat time had a greater affect on attributes tested than microwave power. Consumers select products based on appearance, flavor, and texture and any one of these categories can indirectly affect the other. Although overall texture scored significantly lower, it is unclear if the stickiness of the filling or appearance of filling leakage had a greater affect on overall texture than the texture of the waffle. Future testing would need to address this specifically.

RECOMMENDATIONS

This research identified descriptive methods for bakery products requiring a bite an pull action. Consumer results suggest that a low fat filled waffle product was liked overall as well as full fat waffle products without filling. The results prove promising for consumer acceptability of the product and recommendations for future testing are described below.

Textural problems, such as sogginess, observed during the initial consumer testing (Spring 1997) were corrected by improved microwave reheating methods, a modified susceptor sleeve, and improved sensory testing techniques; however textural optimization would be desirable. Comments by consumers suggested the product was rubbery, chewy, or rough. This indicates moisture is being lost. In addition, crispness was not noted by the majority. Comments of filling stickiness by consumer and descriptive panelists should also be addressed and may well be the most important issue.

In developing the product, fat was simply removed. Flavors were incorporated in the batter and a unique filling was added. Ingredients play a key role in how the product is affected by microwave heating. Adding a fat replacer in the batter could bind more water, reducing loss and provide a more pleasurable overall mouthfeel; however, the replacer might create other textural issues or concerns that might not be any more desirable. Litesse®, a polydextrose fat extender approved for bakery applications and frozen desserts, is soluble in water and contributes little sweetness along with 1 kcal/g. Litesse® could improve texture, bind water, remain stable under acidic conditions, and undergo Maillard browning (Lucca and Tepper, 1994). Polydextrose has contributed to stickiness in some products, so it may not produce all desired results. Another possibility may include a water stabilizer incorporating a combination of shortening, proteins, emulsifiers and stabilizers blended for microwaveable bakery applications (MicroGold, Inc., Oklahoma City, OK). For frozen microwaveable products, a gelatin stabilizer (Wofford Research and

Development of America, El Paso, TX) has controlled the formation of ice crystals that contributes to water loss of the product during storage (Hegenbart, 1992). Our product developed ice crystals that could have softened the texture and created a soggy product. Of concern with any of these applications is increasing toughness of the *Waf-Fill.* An ingredient high in protein, such as egg whites, would toughen the texture and should be avoided. Starch based replacers may be more preferable.

The importance of specific heat in developing a product can be illustrated by the *Waf-Fill.* The fruit filling, with a high solids content and low specific heat, can heat very quickly to high temperatures in the time required to heat the waffle portion. The air cells in the waffle portion decrease the ability to absorb microwaves Reducing the solids content of the filling can slow the heating (Hegenbart, 1992). A reduction in the solids content would also reduce stickiness of the filling.

All descriptive analysis regarding crispness was measured on a corner edge and a center edge, optimal areas for crispness; however consumers were given no instructions in their evaluation. Many evaluated the product at the lowest area of crispness, the center. Most consumers did not finish the entire sample and never reached the end edge. Providing a whole product during testing would be recommended. A scale-up of processing would make this more reasonable as well. Future testing and work on filling appearance and stickiness, on which this study did not focus, should also involve more consumers who are more representative of a general population with a more even distribution of age and sex.

Finally, two new low fat (Hungry Jack and Eggo) and one new fat free (Eggo) frozen waffle products were introduced in this market following our consumer testing. These products do not contain any fruit flavors or fillings and are not microwaveable; however, it would be interesting to test consumer acceptability of *Waf-Fills* along with these products.

REFERENCES

Abbott, J.A. 1972. Sensory assessment of food texture. Food Technol. 26(1): 40-49.

Anonymous. 1983. How to beat the microwave challenge. Food Eng. 55(5): 89-90.

Anonymous. 1989. Obtaining a crisper pizza. Baking and Snack Sys. 11(6): 34.

Anonymous. 1997a. Frozens need relevancy to join HMR revolution. Frozen Food Age 46(5): 16.

Anonymous. 1997b. New data on 'frozen' consumers can improve promos: A C Nielson. Frozen Food Age 45(11): 6.

Anonymous. 1997c. Prepared frozen sales seen hitting $12.3 billion. Frozen Food Age 46(1): 90.

ASTM, 1981. Training of sensory panel members. Ch. 3 in *Guidelines for the Selection and Training of Panel Members*, STP 758. ASTM, Philadelphia, PA.

Bourne, M.C. 1975. Texture properties and evaluations of fabricated foods. In Fabricated Foods, Ed. Inglett, G.E. AVI Publishing Co., Westport, CT

Bramesco, N.P., and Setser, C.S. 1990. Application of sensory texture profiling to baked products: Some considerations for evaluation, definition of parameters and reference products. J. Text. Stud. 21: 235-251.

Brown, D. 1997. Personal communication. James River Corporation, Milford OH

Charlet, K. 1997. It's a wrap. Prep. Foods 166(5): 75-76.

Christensen, C.M., and Vickers, Z.M. 1981. Relationship of chewing sounds to judgments of food crispness. J. Food Sci. 46: 576-578.

Civille, G.V., and Szczesniak, A.S. 1973. Guidelines to training a texture profile panel. J. Text. Stud. 4: 204-223.

Classon, L. 1996. The market for cereal, granola, and energy bars receive nutrition boost. Snack World 85(9): 24-27.

Copson, D.A. 1975. Guide to Domestic Microwave Cooking. Ch. 14 in *Microwave* Heating, p. 335-337. AVI Publishing Co., Westport, CT.

Decareau, R.V. 1992. Fundamentals of microwave heating. Ch. 2 and The microwave oven. Ch. 3 in *Microwave Foods: New Product Development* , p. 48-65, 67-85. Food and Nutrition Press, Inc., Trumbull, CT.

Dornblaster, L. 1997. New products lay low in 1996. Prep. Foods 166(5): 41-42.

Dornblaster, L. 1998a. Baked snack attack. Prep. Foods 167(4): 57-59.

Dornblaster, L. 1998b. Rollin' in dough. Prep. Foods 167(4): 61-62.

Drewnowski, A. 1997. Why do we like fat? J. of the Amer. Dietetic Assn. 97(7): S59-62.

Dwyer, S. 1997. Hey, what's the big idea? Pillsbury knows! Prep. Foods 166(5): 8-9, 16.

Fields, D.M. 1996. The evaluation of taste of low-fat or fat-free snack foods: Do regular purchasers have an upward bias? J. of Food Products Marketing 3(3): 35-45.

Friedman, M. 1998. Unit sales fall for 3rd year in a row; Dollars rise 3.1%. Frozen Food Age 46(8): 1, 10, 12.

Gorton, L. 1997. News and views. Baking and Snack 19(5): 10-11.

Hegenbart, S. 1992. Microwave quality: Coming of age. Food Prod. Design 2(3): 29-52.

Hegenbart, S. 1994. Microwave heating: Nature of the beast. Food Prod. Design 4(1): 23-38.

Iles, B.C. and Elson, C.R. 1972. Crispness. BFMIRA Research Report No. 190.

Katz, E.E., and Labuza, T.P. 1981. Effect of water activity on the sensory crispness and mechanical deformation of snack food products. J. Food Sci. 46: 403-409.

Kohn, S. 1998. An update on the U.S. baking industry. Cereal Foods World 43(3): SR-4-7.

Lucca, P.A., and Tepper, B.J. 1994. Fat replacers and the functionality of fat in foods. Trends in Food Sc. and Technol. 5: 12-19.

Matz, S.A., 1962. Measuring food texture. Ch. 2 in *Food Texture*, p. 12-37. AVI Publishing Co., Inc. Westport, CT.

Munoz, A.M., and Civille, G.V. 1992. The spectrum descriptive analysis method. Ch. 3 in *Manual on Descriptive Analysis Testing*, MNL 13, R.C. Hootman (Ed.), p. 22-34. ASTM, Philadelphia, PA.

Neff, J. 1996. Trends or fad. Food Process. 57(12): 25-27.

O'Donnell. 1997. What will America be eating? Prep. Foods 166(12): 44-45, 48-52.

Posten, R. 1996. Creating the future for baked snacks. Snack Food 85(10): 24.

Posten, R. 1997. Delivering a 'premium' indulgence. Snack and Bakery Foods 86(2): 28, 82.

Postlewaite, K. 1997a. Not just crumbs. Snack and Bakery Foods 86(2): 25-26, 28, 82.

Postlewaite, K. 1997b. In from the cold. Snack Food & Wholesale Bakery 86(12): 18.

Rice, J. 1992. "New wave" susceptors tout improved temperature control. Food Process. 53(11): 93-94.

Robinson, R. 1997a. Bon appetit! New waves of ethnic foods allow us to broaden our culinary horizons. Refrig. & Frozen Fds. 8(9): 49, 53.

Robinson, A. 1997b. C-stores and frozens: Don't count on them. Frozen Food Age 46(1): 1.

Robinson, A. 1997c. 96' IRI Spotlight. Frozen Food Age 45(9): 12, 14.

Rutledge, K.P. 1992. Accelerated training of sensory descriptive flavor analysis panelists. Food Technol. 46 (11): 114-118.

Schiffmann, R.F. 1993. Understanding microwave reactions and interactions. Food Prod. Design 3(1): 72-88.

Schiffmann, R.F. 1997. Microwave technology - A half-century of progress. Food Prod. Design 7(2): 33-56.

Schwartz, N. E. and Borra, S. T. 1997. What do consumers really think about dietary fat? J. of the Amer. Dietetic Assn. 97 (7): S73-., D.D. 1988. Crispness and crunchiness of selected low moisture foods. J. Text. Stud. 19: 79-95.

Staff of New Product News. 1998a. Quality over quantity. Prep. Foods 167(4): 51-52.

Staff of New Product News. 1998b. Twenty tasty trends. Prep. Foods 167(4): 35-36.

Stewart, D. 1996. Bakery trends. Snack Food 85(10): 30-32.

Szczesniak, A.S. 1972. Consumer awareness of and attitudes to food texture. II: Children and teenagers. J. Text. Stud. 3: 206-217.

Szczesniak, A.S. 1988. The meaning of textural characteristics - crispness. J. Text. Stud. 19: 51-59.

Szczesniak, A.S. 1990. Texture: Is it still an overlooked food attribute? Food Technol. 44(9): 86-95.

Szczesniak, A.S., and Kahn, E.L. 1971. Consumer awareness of and attitudes to food texture. I: Adults. J. Text. Stud. 2: 280-295.

Szczesniak, A.S., and Kahn, E.L. 1984. Texture contrasts and combinations: A valued consumer attribute. J. Text. Stud. 15: 285-301.

Szczesniak, A.S., and Smith, B.J. 1969. Observations on strawberry texture. A three pronged approach. J. Text. Stud. 1: 65-89.

Thayer, W. 1997. Retailers select '10 best' new products of the year. Frozen Food Age 46(1): 1.

Vickers, Z.M. 1984. Crispness and crunchiness - a difference in pitch. J. Text. Stud. 15: 157-163.

Vickers, Z.M. 1988. Instrumental measures of crispness and their correlation with sensory assessment. J. Text. Stud. 19: 1-14.

Vickers, Z.M. and Bourne, M.C. 1976. Crispness in foods - A review. J. Food Sci. 41: 1153-1157.

Vickers, Z.M., and Christensen, C.M. 1980. Relationships between sensory crispness and other sensory and instrumental parameters. J. Text. Stud. 11: 291-307.

Wilson, D.R. 1997. Unpublished revised test procedure. IEC U.S. Committee, Frigidaire Home Products, Dublin, OH.

Table A-I

Supplier Information

I. Waffle Ingredients

Unenriched, Untreated Wheat Flour
Cargill, lot # 23:26 12/05/97
Wichita, KS

Granulated Sucrose
Food Club (multiple lots)
Skokie, IL

Salt (iodized)
Morton
Chicago, IL

Double Acting Baking Powder (MCP,SAPP)
ADM)
Olathe, KS

Sodium Benzoate, finely powdered
Diversitiech
Derby, KS

NFDM
ADM, lot #11R100697H
Olathe, KS

SSL
ADM
Olathe, KS

Liquid Whole Eggs, Grade AA Extra Large
Dillon's (multiple lots)
Hutchinson, KS

Crisco Soybean Oil
Procter & Gamble (mulitple lots)
Cinncinati, OH

Natural Strawberry WONF Flavoring
Otten's Flavors
Philadelphia, PA

Pure Vanilla Extract (10 fold)
Otten's Flavors
Philadelphia, PA

Vanilla Extract
Mother Murphy's
Greensboro, NC

II. Filling Ingredients

CstarTex 06230 Modified Corn Starch
Cerestar, lot G2348-13
Hammond, IN

Corn Syrup (42 D.E.)
Cerestar, # 01160
Hammond, IN

Citric Acid (finely granulated)
Haarman & Reimer Corp.
Elkhart, IN

Frozen Whole Strawberries (unsweetened)
Food Club (multiple lots)
Skokie, IL

Red Cabbage Color (liquid)
Warner Jenkinson Co., lot # 34545501
St. Louis, MO

Natural Strawberry WONF Flavoring
Otten's Flavors
Philadelphia, PA

Sunkist® Dried Fruit Leather
Paramount Farms,Inc., lot # 6J02L4EO
Bakersfield, CA

III. Panel Ingredients

Carboxy methylcellulose (powdered)
Aqualon, Hercules, Inc.
Wilmington, DE

IV. Packaging Supplies

Cellophane and Oriented Polypropylene
Gold Medal Products, Co.
Cincinnati, OH

Susceptor Sleeves
Fort James Corp.
Milford, OH

Zipper Freezer Bags (1 gallon)
Wal-Mart® Stores, Inc.
Bentonville, AR

Zipper Snack Bags
Glad-lock®

V. Equipment

Belgian Waffle Iron (640 watt)
K-mart Kitchen Basics, model WB-957
High Performance Appliances, Inc.,
Danbury, CT

Oral Medication Syringe for Injection (20 cc)
Apex Medical Corp.,
Sioux Falls, SD

650 watt Microwave
Sharp Carousel, model R-9700
Mahwah, NJ

1000 watt Microwave
Sharp Carousel Sensor, model R-320AK
Mahwah, NJ

1500 watt Microwave
Amana Radarange, model RR-7DA
Amana, IA

Wide Slot 4 Slice Toaster
Toastmaster® Inc., model D1051
Boonville, MO

19 L Hobart Mixer
Hobart Co., model A-200
Troy, OH

Table A-II

References used by descriptive panelists for evaluations of *Waf-Fills*

Reference	Description
A	• Plain Waf-Fills (2 min 15 s) defrost 15 min and warmed 3 min in preheated 190.6°C oven (Rm. 144) • Defrost 1:45-2 pm, cook 2:00 pm (ovens 4 & 5), cool til 3:10 pm on rack
B	• Plain Waf-Fills (3 min) defrost 15 min and warmed 10 min in preheated 204.4°C oven, rotate after 5 min on cookie sheet (Rm. 144) • Defrost 1:45-2 pm, cook 2:00 pm, (ovens 1 & 2),cool til 3:10 pm on rack
C	uneven color for Waf-Fill (from first set in iron)
D	even color for Waf-Fill (selected for color evenness)
E	light color for Waf-Fill (2 min precook, 30 s microwaved)
F	dark color for Waf-Fill (4 min precook, 45 s microwaved)
G	browning appearance (occurred naturally during heating)
H	moderate scorching appearance (heated uneven Waf-Fill in oven)
B	high surface roughness (204.4°C 10 min)
J	moderately scorched toast (flavor)
K	darkly scorched toast (flavor)
L	lightly scorched toast (flavor)
M	dark scorching appearance (heated Waf-Fill in microwave)
N	light scorching appearance (heated uneven Waf-Fill in oven)
Wonder Bread	Unfrozen fresh large loaf (cut in 0.6 cm squares)
Crispix	Kellogg's corn and rice cereal

Form A-III

Waf-Fill Descriptive Evaluation Techniques and Definitions

APPEARANCE

I. Evaluation Techniques:

A. Initial Presentation
- Set timer for 2 minutes and begin appearance evaluation
- Evaluate *Scorched Appearance, Color Evenness, and Color Lightness*

II. Definitions:

***Browning Appearance*:** Perceived browning on the **top or bottom surface** of the product. This does not contain any shades of black color.

Scorched Appearance: Perceived burning present on the **top or bottom surface** of the product. If present evaluate the degree of burning and note *specifically* on the diagram where it was observed.

Color Evenness: Evaluate the uniformity of color across the top surface of the waffle. If a color gradient is observed then this would not be considered even.

***Color Lightness*:** Evaluate the color (light versus dark brown) of the center 4 squares on the top surface of the waffle.

III. References:

Scorched Appearance

(standard Waf-Fill with browning, not scorched = Reference G)

(standard Waf-Fill with light scorching = Reference H)
(standard Waf-Fill with dark scorching = Reference M)

(standard Waf-Fill without browning or scorching = Reference E)

Degree of Scorching

(Waf-Fill G = 3.5, Waf-Fill N = 5.0, Waf-Fill H = 7.0, Waf-Fill M = 8.5)

Color Evenness

(Waf-Fill C = 2.0, Waf-Fill E = 6.0, Waf-Fill D = 8.0)

Color Lightness

(Waf-Fill E = 1.0 and 3.5, Waf-Fill F = 8.0)

TEXTURE

I. Evaluation Techniques, Definitions, and References:

After 2 minute timer sounds following the appearance evaluation, evaluate in the following order:

a. Set timer for 1 minute and evaluate the dark end

b. **First evaluate all of the following with <u>one</u> lower left corner bite (dark end):**

1. *toughness*
2. *scorched flavor* (if most scorched area, perform in 10 chews with 1 chew/ sec.)

(Toughness) Bite and Pull:

The amount of force required to pull product away after biting. Evaluate by bringing incisors together on an unbroken edge surface and pull away with a steady force.

- Dark Side
  Evaluate during first bite by biting on the **lower left** unbroken edge **corner** surface of the **dark (short side)** end.

- Light Side
  Evaluate separately on the **center edge** by biting on an unbroken edge surface of the **light (short side)** end.

<u>REFERENCES</u>

(Wonder bread = 1.0, Reference A* = 5.0, Reference B* = 7.0)

* Evaluate reference following the same procedure described for dark side toughness

---

c. **Secondly evaluate all of the following with <u>one</u> upper left corner bite (dark end):**

1. *incisor crispness*
2. *surface roughness*
3. *scorched flavor* (if most scorched area, perform in 10 chews with 1 chew/ sec.)

Incisor Crispness:

Perceived high frequency, sharp sound, as the incisors enter the product.

- Dark Side
  Evaluate during the second bite by biting on the **upper left corner** surface of the **dark (short side)** end.

- Light Side
  Evaluate separately on the **center edge** by biting on an unbroken edge surface of the **light (short side)** end.

REFERENCES

(Reference A* = 3.5, Reference B* = 6.0, Crispix = 8.0)

* Evaluate reference following the same procedure described for crispness.

Surface Roughness:

Degree of abrasiveness on the palate. Evaluate during the second bite by biting on the edge corner surface of the dark (**short side**) end. Press gently against the palate and evaluate using the tongue. *Do not chew!*

REFERENCES

(Reference A = 4.5, Reference B = 8.0)

---

d. Set timer for 1 minute and evaluate the light end:

e. **Evaluate all of the following with one center short edge bite (light end):**

1. *incisor crispness*
2. *toughness*
3. *scorched flavor* (if most scorched area, perform in 10 chews with 1 chew/ sec.)

f. If the **most scorched area was not present during the b, c, or e evaluations**, but is observed elsewhere on the Waf-Fill, evaluate that area for scorched flavor **after all other evaluations**.

FLAVOR

I. Evaluation Techniques:

Evaluate the **most scorched area.** If present, indicate the flavor of the most scorched area.

- Evaluate the most scorched area, with a bite size the size of the scorched area, after 10 chews at the rate of 1 chew per second.

II. Definition:

Scorched Flavor: An observed burnt, acrid note. The flavor is highly bitter and mildly astringent associated with high crispness. Evaluate the most scorched area for aroma and taste. Taste is evaluated during mastication of the most scorched area.

III. References:

Scorched Flavor
(Lightly scorched toast = Reference L = 1.5)
(Moderately scorched toast = Reference J = 6)
(Highly scorched toast = Reference K = 8.5)

Form A-IV

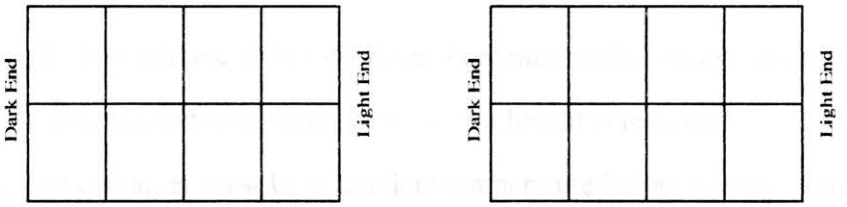
***Waf-Fill* Ballot**

Name: _____ Date: _____

Texture Evaluation of 130

Stage I. Appearance *(Evaluate for 2 minutes)*

Browning and Scorching Observations: ***(Circle any brown/ scorched area(s). Mark an S on the scorched black surface(s) if present)***



Comments:

Degree of Scorching (most scorched area)	0 none	0.5	1	1.5	2	2.5	3	3.5 G	4	4.5	5 N	5.5	6	6.5	7 H	7.5	8	8.5 M	9 high
Color Evenness (top side)	0 uneven	0.5	1	1.5	2 C	2.5	3	3.5	4	4.5	5	5.5	6 E	6.5	7	7.5	8 D	8.5	9 even
Color Lightness: (top side)	0 light	0.5	1 E	1.5	2	2.5	3	3.5 E	4	4.5	5	5.5	6	6.5	7	7.5	8 F	8.5	9 dark

Stage II. Dark Corner Bite *(Evaluate first for 1 minute)*

A. Lower left corner:

Toughness	0 none	0.5	1 Bread	1.5	2	2.5	3	3.5	4	4.5	5 A	5.5	6	6.5	7 B	7.5	8	8.5	9 high

B. Upper left corner:

Incisor Crispness	0 none	0.5	1	1.5	2	2.5	3	3.5 A	4	4.5	5	5.5	6 B	6.5	7	7.5	8 Crispix	8.5	9 high
Surface Roughness	0 none	0.5	1	1.5	2	2.5	3	3.5	4	4.5 A	5	5.5	6	6.5	7	7.5	8 B	8.5	9 high

Stage III. Light Center Bite *(Evaluate next for 1 minute)*

Incisor Crispness	0 none	0.5	1	1.5	2	2.5	3	3.5 A	4	4.5	5	5.5	6 B	6.5	7	7.5	8 Crispix	8.5	9 high
Toughness	0 none	0.5	1 Bread	1.5	2	2.5	3	3.5	4	4.5	5 A	5.5	6	6.5	7 B	7.5	8	8.5	9 high

Stage IV. Remaining Bite *(Evaluate if not observed above in stages II or III)*

Scorched Flavor (most scorched area)	0 none	0.5	1	1.5 L	2	2.5	3	3.5	4	4.5	5	5.5	6 J	6.5	7	7.5	8	8.5 K	9 high

Table A-V

International Electrotechnical Commission (IEC) 705, 3rd edition Test Procedure for Power Output (Summarized)[a]

Notes: Do not operate the microwave for at least 6 hr. Ambient temperature is 20 ± 5°C. Potable water is heated to ambient temperature to ensure heat loss and heat capacity of the container has a minimum effect. A correction factor is accounted for. Water temperature is critical and must be accurately measured by stirring prior to measuring using a device with a low heat capacity.

1. The mass of a borosilicate glass cylindrical container with dimensions of 3 mm thickness x 190 mm external diameter x 90 mm height is recorded.
2. The oven and container must be at ambient temperature before testing. Initial water temperature (10 ± 1°C) is recorded immediately before adding to the container.
3. The mass of 1000 ± 5 g of water and container are recorded and immediately placed in the center of the oven.
4. The time required to heat the water to 20 ± 2 °C is required. The final water temperature is measured within 60 s.

Formula:

$$P = \frac{4.187 \times m_w \times (T_2 - T_1) + 0.55 \times m_c \times (T_2 - T_0)}{t}$$

P = microwave power output (watts)
m_w = water mass (g)
m_c = container mass (g)
t = heating time (s)

T_0 = ambient temperature (°C)
T_1 = initial water temperature (°C)
T_2 = final water temperature (°C)

[a] *Adapted from: Wilson, 1997*

Table A-VI

Two-Liter Test for Determining Microwave Power[a]

1. In two, one-liter beakers at an ambient temperature, add 2000 ± 5 g of water with an initial temperature of 20 ± 2°C (stir well with a plastic spoon before recording). The thermometer should have at least 0.1°C of resolution.
2. The beakers are placed touching each other parallel to the width of the oven in the center of the oven.
3. The microwave is heated for 2 min 2 s and the final water temperatures are recorded (stir well with a plastic spoon before recording).
4. Repeat this test three times . The average of the three powers represents oven power. If any one measure is greater than 5% of the average power, the entire test must be repeated.

Formula: Power (watts) = 35 x [ΔT_1(°C) + ΔT_2(°C)]

ΔT_1 = change in water temperature in beaker one

ΔT_2 = change in water temperature in beaker two

[a] *Adapted from: Hegenbart, 1992*

Table A-VII

One-Cup Test For Distinguishing Between High and Low Power Microwaves[a] for Use By Consumer

1. Fill a container with half water and half ice and add exactly 1 cup of water (no ice) to a glass measuring cup.
2. Place the cup in the center of the microwave and heat on "high".
3. If the water boils in less than 3.5 min, the oven is a "high" power oven. If the water takes longer to boil, then it is a "low" power oven.

[a] Adapted from: Hegenbart, 1992

Table A-VIII

Analysis of Variance results for appearance attributes of *Waf-Fills* reheated in a microwave at 650 watts for 60 s, 650 watts for 75 s, 1000 watts for 50 s, 1000 watts for 60 s, and 1000 watts with sensor

Attributes	Degrees of Freedom (Numerator)	Numerator	Degrees of Freedom (Denominator)	Denominator	F Value	Pr>F
Scorch						
Panelist	5	1.04	10	0.96	1.08	0.4280
Treatment	4	3.79	8	0.54	7.08	0.0097
Panelist*Treatment	20	0.53	40	0.56	0.95	0.5373
Color Evenness						
Panelist	5	3.12	10	0.54	5.83	0.0089
Treatment	4	0.50	8	0.47	1.05	0.4402
Panelist*Treatment	20	0.78	40	1.27	0.61	0.8802
Color Lightness						
Panelist	5	4.01	10	0.23	17.22	0.0001
Treatment	4	0.16	8	0.30	0.52	0.7283
Panelist*Treatment	20	0.29	40	0.42	0.68	0.8214

Table A-IX

Analysis of Variance results for dark corner textural attributes of *Waf-Fills* reheated in a microwave at 650 watts for 60 s, 650 watts for 75 s, 1000 watts for 50 s, 1000 wa for 60 s, and 1000 watts with sensor

Attributes	Degrees of Freedom (Numerator)	Numerator	Degrees of Freedom (Denominator)	Denominator	F Value	Pr>F
Toughness (DC)						
Panelist	5	10.57	10	2.24	4.71	0.0180
Treatment	4	1.96	8	0.85	2.30	0.1473
Panelist*Treatment	20	0.78	40	0.69	1.13	0.3575
Crispness (DC)						
Panelist	5	6.36	10	0.55	11.64	0.0007
Treatment	4	19.31	8	1.33	14.54	0.0010
Panelist*Treatment	20	1.68	40	1.00	1.68	0.0807
Surface Roughness						
Panelist	5	27.40	10	0.56	49.28	0.0001
Treatment	4	12.11	8	1.70	7.10	0.0096
Panelist*Treatment	20	1.36	40	0.99	1.37	0.1921

Table A-X

Analysis of Variance results for light center textural attributes of *Waf-Fills* reheated in a microwave at 650 watts for 60 s, 650 watts for 75 s, 1000 watts for 50 s, 1000 w for 60 s, and 1000 watts with sensor

Attributes	Degrees of Freedom (Numerator)	Numerator	Degrees of Freedom (Denominator)	Denominator	F Value	Pr>F
Toughness (LC)						
Panelist	5	10.62	10	1.81	5.88	0.0086
Treatment	4	0.95	8	0.66	1.44	0.3063
Panelist*Treatment	20	0.95	40	1.04	0.92	0.5724
Crispness (LC)						
Panelist	5	13.55	10	1.11	12.18	0.0005
Treatment	4	18.93	8	3.65	5.19	0.0233
Panelist*Treatment	20	0.88	40	0.82	1.08	0.4072

Table A-XI

Probabilities from Least Squares Means tests comparing effects across dark corner and light center portions of the *Waf-Fill* by the descriptive panel

Treatment	Toughness Pr>F	Crispness Pr>F
650 watts / 60 s	0.9065	0.2840
650 watts / 75 s	0.5574	0.1098
1000 watts / 50 s	0.3489	0.0018
1000 watts / 60 s	0.4817	0.0048
1000 watts / sensor	0.4120	0.0025

Form A-XII

Prescreener Used for Consumer Testing

Date: _____ **Recruited:** _____

Project Objective: If you are selected , you will be paid $5 for your opinions on four food products. The session should last about 30 minutes and will be conducted in Justin hall.

Availability: Please circle **all possible times** in which you would be available to participate in this study:

Monday morning, **April 20:** 8:30 - 9:00 9:30 - 10:00 10:30 - 11:00

Tuesday morning, **April 21:** 8:30 - 9:00 9:30 - 10:00 10:30 - 11:00

Background:

Name: _____

Address: _____ Manhattan, KS _____

Phone (home and business): H:_____B:_____Best time to call_____

Sex: M F

Age: _____18 to 24 yrs _____25 to 34 yrs _____35 to 45 yrs _____other

Health:

Do you suffer from any food allergies? Y N

Do you have to avoid any foods such as sugar or salt? Y N

General Info:

1. Do you consume breakfast products? Y N
2. Do you currently consume breakfast items which can be prepared in 5 minutes or less? Y N
3. Could these items be eaten on-the-run? Y N
4. Please indicate how often you consume the following:

   a) Cereal Bars
   _____not familiar with _____never _____/ two weeks or _____/ month

   b) Donuts/ Pastries
   _____not familiar with _____never _____/ two weeks or _____/ month

   c) Frozen Waffles
   _____not familiar with _____never _____/ two weeks or _____/ month

d) Frozen Breakfast Sandwich
_____not familiar with _____never _____/ two weeks or _____/ month

e) Bagels
_____not familiar with _____never _____/ two weeks or _____/ month

f) Toaster Strudels
_____not familiar with _____never _____/ two weeks or _____/ month

g) Granola Bars
_____not familiar with _____never _____/ two weeks or _____/ month

h) Toaster Pastries (ex. Pop-Tarts)
_____not familiar with _____never _____/ two weeks or _____/ month

5. Circle which 3 fruit flavors would you most likely purchase or consume for the previous type products? *(Indicate your favorite flavor with an F if it pertains. Indicate any you dislike with a D.)*

Apple Blueberry Cherry Peach Raspberry Strawberry Other: _____

6. How long would you allow a microwaveable product to cool after heating before taking a bite? _____

Form A-XIII

Informed Consent Form Used by Consumers

INFORMED CONSENT STATEMENT

You have been asked to participate in a sensory consumer testing of on-the-go food products. You are expected to take not more than 35 minutes to complete testing of these products. All ingredients are food grade. There will be no foreseeable risks or discomforts regarding these food products; however **if you are allergic to any type of food or must watch your consumption of sugar or salt due to medical reasons, please notify one of the people in charge of sensory testing at this time.** If an adverse reaction has been experienced after or during the testing, please contact Dr. Fadi Aramouni at 216 Call Hall, (785) 532-1668 or Dr. Carole Setser at 143D Justin Hall, (785) 532-0172. Your data will be treated as research data and will in no way be associated with you other than for identification purposes, thereby assuring confidentiality of your performance and responses.

1. I (print) _____, agree to participate as a panelist in research conducted by Dr. Fadi Aramouni and his graduate student, Sherry Frey.

2. I understand that this study is part of a thesis project and it is to determine how much consumers like the on-the-go food products.

3. I understand that all ingredients used in this study are commercially available.

4. I understand that there will be payment of $5 upon completion of this session.

5. I understand that if I choose not to participate, there will be no penalty.

6. I understand that I may withdraw from the testing area at any time.

7. If I have any questions concerning this study, I understand that I can contact Dr. Fadi Aramouni, 216 Call Hall, (785) 532-1668 or Dr. Carole Setser at 143D Justin Hall, (785) 532-0172.

8. If I have any questions about my rights as a panelist or about the manner in which the study is conducted, I may contact the Committee on Research Involving Human Subjects, 103 Fairchild Hall, Kansas State University, Manhattan, KS 66506, at (785) 532-6195.

_____ Date _____

(Signature)

Panelist # _____

Form A-XIV

Ballot Used for Consumer Test

Panelist Number: _____ Session: _____

Consumer Questionnaire for Product 024

- Before tasting the product, please rinse your mouth by taking a bite of cracker and a drink of water.
- Evaluate the product in front of you by looking at it and tasting it.
- Considering ALL characteristics (APPEARANCE, FLAVOR, and TEXTURE), circle the number which corresponds to your overall opinion of the product.

1	2	3	4	5	6	7	8	9
dislike extremely				neither like nor dislike				like extremely

Comments: Please indicate WHAT in particular you liked about this product. (USE WORDS NOT SENTENCES)

LIKED	DISLIKED
_____	_____
_____	_____
_____	_____

LIKING QUESTIONS

- Please retaste the product to indicate how much you LIKE or DISLIKE the following. *Circle the number that best represents your response.*

Overall Appearance

1	2	3	4	5	6	7	8	9
dislike extremely				neither like nor dislike				like extremely

Overall Flavor

1	2	3	4	5	6	7	8	9
dislike extremely				neither like nor dislike				like extremely

Filling Flavor

1	2	3	4	5	6	7	8	9
dislike extremely				neither like nor dislike				like extremely

Overall Texture

1	2	3	4	5	6	7	8	9
dislike extremely				neither like nor dislike				like extremely

Filling Texture

1	2	3	4	5	6	7	8	9
dislike extremely				neither like nor dislike				like extremely

Form A-XV

Post Evaluation Questionnaire Given to Consumers

Panelist No.:_____ Session: _____

Age: _____18 to 24 _____25 to 34 _____35 to 45 Sex: M F

Questions to be answered after testing

(Products are listed in alphabetical order):

1. Would you consider any of the products as a **snack item** in addition to a breakfast item? Y N

   If yes, circle which one(s):

   Strudel w/ strawberry filling *Toaster Pastry w/ strawberry filling* *Waffle w/ strawberry filling* *Waffle w/ strawberry pieces*

2. Would the **fat content** influence your consumption of any of these products?

   Y N

   Please circle which would you prefer: low fat regular fat does not matter

3. For products which can be heated quickly and eaten on-the-run, would your decision to purchase or consume the product be influenced by the heating method? Y N

   If yes, I would prefer to heat products quickly with a: microwave toaster

4. Based on the **texture**, do you think any product was reheated using a microwave?

   Y N

   If yes, circle which one(s):

   Strudel w/ strawberry filling *Toaster Pastry w/ strawberry filling* *Waffle w/ strawberry filling* *Waffle w/ strawberry pieces*

5. Which product was your **favorite overall**?

   Strudel w/ strawberry filling *Toaster Pastry w/ strawberry filling* *Waffle w/ strawberry filling* *Waffle w/ strawberry pieces*

Form A-XVI

Follow-up Questionnaire Used with Selected Consumers

Follow-up questions to be answered 2-3 days after testing

1. According to the questions you answered at the end of the consumer test, you indicated that fat would influence your consumption of the products tested and you would prefer a low fat product . Knowing that PER SERVING:

   a) the Toaster Strudel had 9 g of fat,
   c) the Waffle with strawberry pieces had 8 g of fat,
   b) the Toaster Pastry had 5 g of fat, and
   d) the waffle with strawberry filling had 3 g of fat

   Would you have still preferred the *their selection* overall? Y N
   (They did not initially choose the low fat Waf-Fill)

   Please rank your order of preference with 1 being the most preferred

2. For products that could be heated quickly and eaten on-the-run, you indicated that you would prefer to heat with a microwave. Knowing that on the waffle with strawberry filling was the only product heated in a microwave for 50 seconds, while the other three products were heated for 1 to more than 2 minutes using a toaster, would you still have preferred the *their selection* as your favorite product overall?
   Y N

   If no please rank your preference with 1 being the most preferred.

   a) the Toaster Strudel took over 2 minutes in a toaster or 3 sec in microwave
   c) the Waffle with strawberry pieces took 1 minute 43 seconds in a toaster
   b) the Toaster Pastry took about 50 seconds in a toaster
   d) the waffle with strawberry filling had 3 g of fat and took 50 seconds in a microwave

Table A-XVII

Presentation Order Used for Consumer Acceptability Testing of Four Products

Booths	Presentation Order			
1-3	A[a]	B[b]	C[c]	D[d]
4-6	B	D	A	C
7-9	C	A	D	B
10-12	D	C	B	A

[a] A = Toaster Strudel
[b] B= Pop-Tart
[c] C = Eggo waffle
[d] D = Waf-Fills

Table A-XVIII

Consumer Panel Analysis of Variance Results for Panelist and Treatment Effects

Attributes	F Value	Pr>F
Overall Acceptability		
Panelist	1.34	0.0972
Treatment	13.46	0.0001
Overall Appearance		
Panelist	2.49	0.0001
Treatment	14.44	0.0001
Overall Flavor		
Panelist	1.31	0.1103
Treatment	12.98	0.0001
Filling Flavor		
Panelist	1.51	0.0306
Treatment	9.37	0.0001
Overall Texture		
Panelist	1.46	0.0419
Treatment	11.25	0.0001
Filling Texture		
Panelist	2.08	0.0004
Treatment	14.98	0.0001

Table A-XIX Probabilities from Analysis of Variance Results for Acceptability of KSU *Waf-Fills*, Kellogg's Eggo Waffle, Kellogg's Pop-Tart, and Pillsbury Toaster Strudel

Attributes	Pr>F	Attributes	Pr>F	Attributes	Pr>F
Overall Acceptability		**Overall Flavor**		**Overall Texture**	
Waf-Fills and Pop-Tart	0.1738	*Waf-Fills* and Pop-Tart	0.5165	*Waf-Fills* and Pop-Tart	0.0537
Waf-Fills and Eggo waffle	0.7949	*Waf-Fills* and Eggo waffle	0.8271	*Waf-Fills* and Eggo waffle	0.0076
Waf-Fills and Toaster Strudel	0.0001	*Waf-Fills* and Toaster Strudel	0.0001	*Waf-Fills* and Toaster Strudel	0.0001
Pop-Tart and Eggo waffle	0.2696	Pop-Tart and Eggo waffle	0.3885	Pop-Tart and Eggo waffle	0.4390
Pop-Tart and Toaster Strudel	0.0001	Pop-Tart and Toaster Strudel	0.0001	Pop-Tart and Toaster Strudel	0.0002
Eggo waffle and Toaster Strudel	0.0001	Eggo waffle and Toaster Strudel	0.0001	Eggo waffle and Toaster Strudel	0.0033
Overall Appearance		**Filling Flavor**		**Filling Texture**	
Waf-Fills and Pop-Tart	0.5727	*Waf-Fills* and Pop-Tart	0.2114	*Waf-Fills* and Pop-Tart	0.1134
Waf-Fills and Eggo waffle	0.4572	*Waf-Fills* and Eggo waffle	0.1851	*Waf-Fills* and Eggo waffle	0.4430
Waf-Fills and Toaster Strudel	0.0001	*Waf-Fills* and Toaster Strudel	0.0002	*Waf-Fills* and Toaster Strudel	0.0001
Pop-Tart and Eggo waffle	0.8545	Pop-Tart and Eggo waffle	0.0114	Pop-Tart and Eggo waffle	0.0212
Pop-Tart and Toaster Strudel	0.0001	Pop-Tart and Toaster Strudel	0.0112	Pop-Tart and Toaster Strudel	0.0002
Eggo waffle and Toaster Strudel	0.0001	Eggo waffle and Toaster Strudel	0.0001	Eggo waffle and Toaster Strudel	0.0001

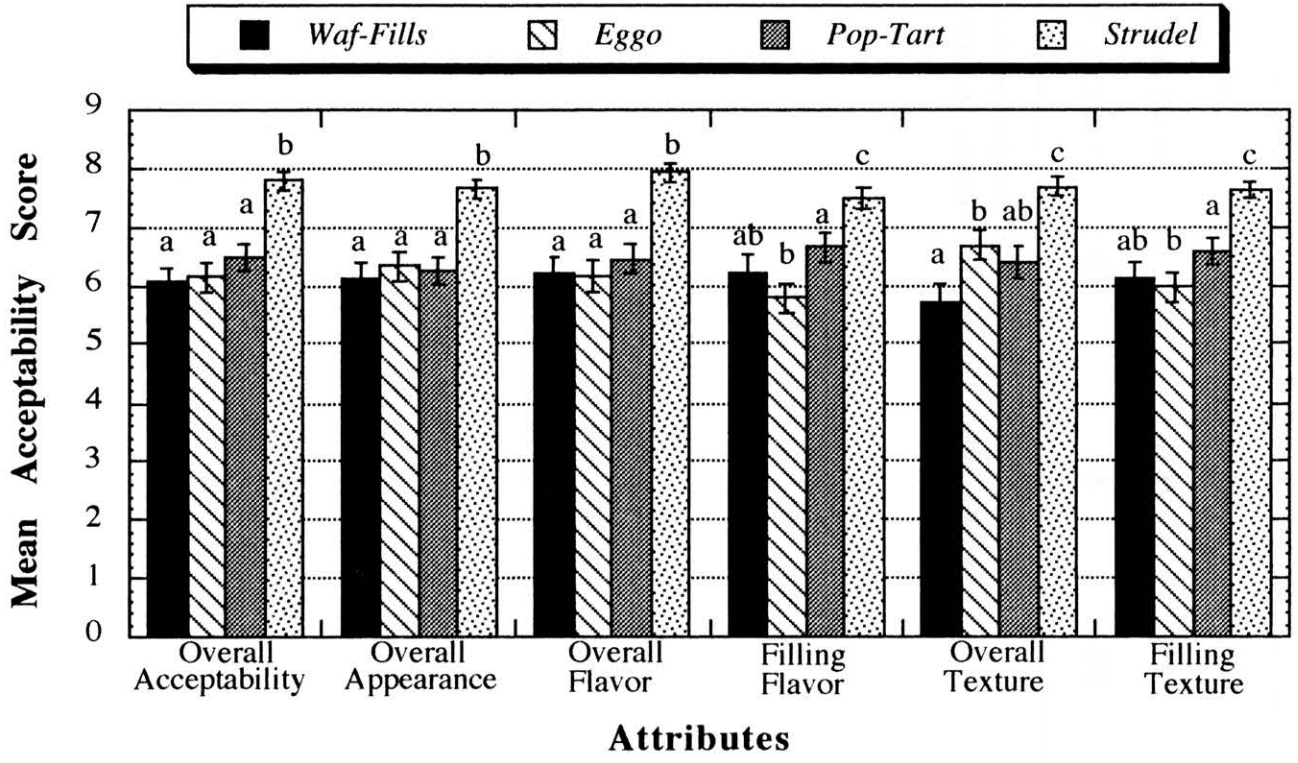


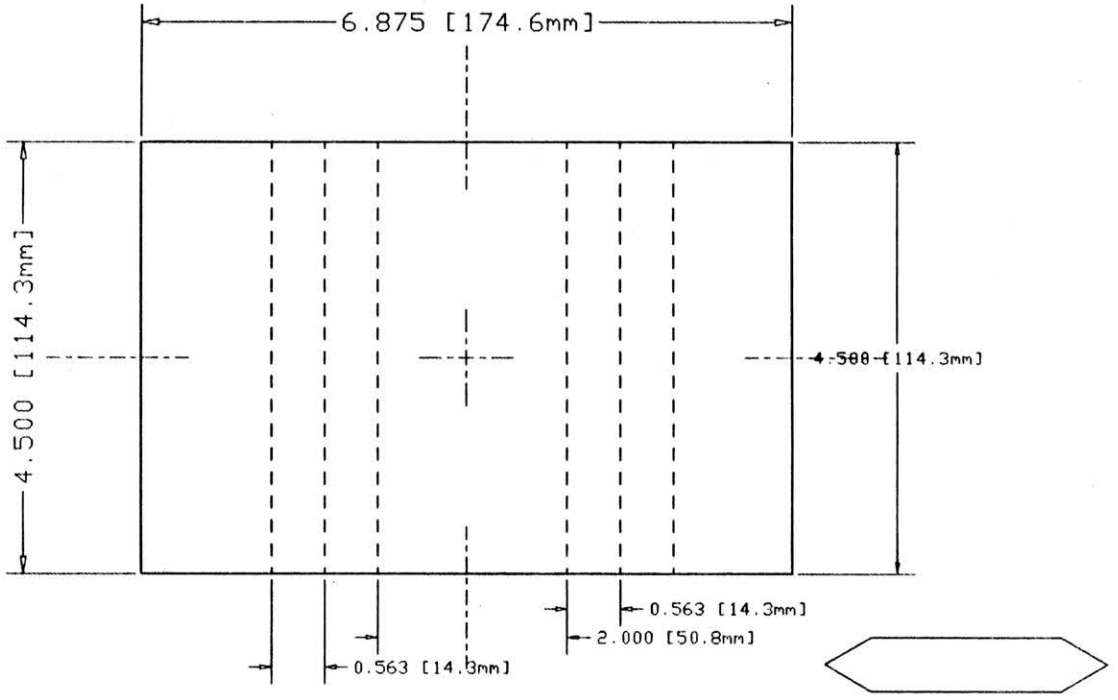
Fig.A-XX-Consumer panel (n = 51) acceptability scores for KSU Waf-Fills with strawberry filling, Pillsbury Toaster Strudel with strawberry filling, Kellogg's Eggo waffle with strawberry pieces, and Kellogg's Pop-Tarts with strawberry filling.

Table A-XXI-Initial consumer acceptability testing of *Waf-Fills*[a]

	Overall Product	Strawberry Filling Flavor	Waffle Texture	Waffle Color	Strawberrry Filling Color
Mean Score	7.00	7.33	6.53	7.28	7.84
Standard Error	0.18	0.19	0.25	0.21	0.17
% Top 3 Box[b]	67	78	52	71	90

[a] Conducted in Spring 1997 (n = 58)

[b] Percentage of panelists who assigned a score of 7 or better.



PH. 513-576-7019 FAX 513-576-7105	O.A. 30.9	CUSTOMER: Chef America	SIZE: 2 x 1.125 x 4.5	DWG. NO.: DC71334
PRINT SIDE	DRAWN BY: R.J.R.	ITEM: Waf-Fills	STYLE: MW Glued Sleeve	FORT JAMES ONE BETTER WAY RD. MILFORD, OH 45150-2743
		PREV. NO.:	DATE: 11/18/97	STOCK: .0145 Quick Crisp
		THIS DRAWING IS FOR SAMPLE MAKING PURPOSES ONLY AND IS NOT TO BE USED FOR FINAL PRODUCTION. FINAL GRAPHICS AND OTHER PRODUCTION MATERIALS MUST CORRESPOND WITH THE PRODUCTION DIE DRAWING.		

Fig.A-XXII - Susceptor sleeve diagram (unfolded)