

DETERMINING A SENSORY MODEL FOR PREDICTING SUCCESSFUL AND
UNSUCCESSFUL PRODUCTS: A CASE STUDY OF FLAVORS FOR A SNACK
CATEGORY

by

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B.S., University of Tennessee, Knoxville, 2003
M.S., Kansas State University, 2005

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Human Nutrition
College of Human Ecology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

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Abstract

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Most methods chosen for this research are commonly used. However, previous research has identified a relationship between consumers liking and salivation, without defining a method. Thus, three salivation methods were selected for initial testing: spit, cotton rolls and sensory scale. These were tested on foods with different textures. Although all methods gave similar results, the spit method was chosen for further testing of flavor differences. Differences in salivation measurements were found for snacks where flavors were different but texture was unchanged.

Next, flavored snack products from 15 countries were selected that were successful or had failed. Questionnaires were completed for each product and included questions related to authenticity, familiarity, current trends, packaging and marketplace issues such as product competition and pricing, all of which would be known before launch. A discriminant function was developed that correctly identified 75.8% of the successful flavored snack products as successful and 66.7% of the unsuccessful products as unsuccessful. Stepwise comparisons were used to determine that four variables are necessary to correctly categorize these products.

The products then were clustered into three groups to select 34 products from 11 countries for further sensory testing. Information from extensive sensory descriptive methods were evaluated individually and in various combinations through stepwise regression and discriminant analysis. The final sensory model correctly predicted all successful and unsuccessful products, had an R-square of 0.84 and included nine regression factors: seven flavor attributes and two flavor attribute ratios. Many of the attributes were base flavor notes necessary for this flavored snack category. A process for selecting key attributes for success was described. For this snack category, creating products with flavors that interact well with base flavor notes can lead to a successful product.

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Dedication

I would like to dedicate this dissertation to my family. Particularly, to my parents, Jane and David Doan, who emphasized the importance of education and supported me through life lessons as I encountered them. My siblings, Elizabeth, Lucinda, Deborah and David Bruce who have been anchors for me through-out my entire life and who I challenge to reach their own dreams. To my niece and nephew, Hannah and Mattheus, who simply bring joy to my life whether it is over the phone or in-person. Also, to Kelly Thompson for her endless patience and understanding through everything!

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"SOME PEOPLE DREAM OF SUCCESS. . .WHILE OTHERS WAKE UP AND WORK HARD AT IT." - ANONYMOUS

CHAPTER 1 - Review of Literature

"SUCCESS ON ANY MAJOR SCALE REQUIRES YOU TO ACCEPT RESPONSIBILITY. . .IN THE FINAL ANALYSIS, THE ONE QUALITY THAT ALL SUCCESSFUL PEOPLE HAVE. . .IS THE ABILITY TO TAKE ON RESPONSIBILITY." - MICHAEL KORDA

New Products

Many companies invest millions into new and existing products and promotions to increase market share (Watson, 2003). As the market grows, food companies must always be looking for new ways to develop new products and uniquely launch them into the marketplace.

A new product for a company can take a variety of paths:

- New technologies
- New concepts
- New raw materials
- Line extensions
- Revive old products with new uses
- Copy a product already in the market
- New target audience for existing product

Any and all of these paths can lead to the launch of a product into the market. The idea, for every company, is to increase competitive advantage and improve in the market (Hanchate, 2006). Launching a product that can withstand the life cycle ahead of it results in a successful product.

Product life cycle is important to understand and explains how long the product lasts in the marketplace (Dean, 1969). The cycle includes five stages, according to Hanchate (2006), that are used to discuss how a product moves from launch into the market and then removal from the shelf. The introduction stage has slow growth with heavy marketing and no profit. Stage two includes strong growth with repeat purchases from previous consumers and first time buyers trying out the product. The third stage is the maturity phase where there is a slower rate of

growth and the market is becoming saturated. Now, the market has become saturated and no new growth for the product is occurring (Hanchate, 2006). The final stage removes the product from the market because sales have dropped off and there is no profit. Having the most profit from the product is critical and staying in the maturity stage longer will yield the best profit. The best way for a company to stay in the maturity stage is to have more products introduced into the market right after each other (Tibben-Lembke, 2002; Lambkin and Day, 1989; Polli and Cook, 1969).

Of particular importance to product developers are the stages of development that occur before launch. Jones and Jew (2007) identified a cycle of innovation to help companies keep new product ideas generating constantly throughout the year. Including multiple departments of the company into the decision making process helps to include all expertise that is necessary to be considered before a launch, this would include areas such as research and development, marketing and consumer groups (Wilson, 1994). Having the team creating as many concepts as possible will help the process because there are more concepts created that go into the cycle than what finishes with a successful launch. Another part of the innovation cycle is the importance of academia working with the industry on topics that can be beneficial in optimizing concepts that lead to success for both academics and industry (Jones and Jew, 2007).

There is a natural progression of optimizing a product for launch into the marketplace. A basic process would be to start with an idea, investigate/innovate the idea, develop a product, pre-release production and then launch into production (Wilson, 1989). At the end of each phase there would be an evaluation of the phase to help decide if the process should continue. An example of an evaluation that may take place is the go/no go where collected information is presented and the team will determine if there is enough support to continue or stop the project

(Wilson and Norton, 1989). Other methods have expanded on this process by including more detailed steps. Additional steps could begin with corporate decisions to start creating an idea, idea creation stage, business analysis, concept development and teaching, develop product brief, product development, costing and economic evaluation, market testing, scale-up with production trial, finishing with commercialization and product launch (Hanchate, 2006).

Expanding in the product development area includes proper formula optimization and testing products with consumers to assure attributes are delivering on concepts that were developed during the ideas stage (Jones and Jew, 2007). The product development process is multi-stage and in order to get the best end results possible continuing to strategize with representatives from each part of the company will assure aspects are not over looked like labeling laws and health claim ads, if they apply (Cappellano, 2009).

Market Success

Market success is a complex term that is associated with a product that is accepted in the marketplace by consumers and has repeat purchasing from consumers yielding a profit for the company (Hanchate, 2006; Kristensen *et al.* 1998). Designing a strategy that can bring a continuous wave of new products into the marketplace before competitors do is difficult (Fortuin *et al.* 2007). After all, there are only so many innovative projects that turn out to be successful products (Cooper, 1999).

With consumer trends constantly changing, new improvements in technology and more competitors, it is difficult to stay at the top of the pack in the marketplace (Fortuin *et al.* 2007). Keeping a watch on past trends to see if they are positive or negative reactions occurring in the market helps to predict longer product life (Sheldrake, 2008). Many researchers have had their own opinions about improving success in the marketplace. Some of these focus on the whole

process required to get the product ready for launch, prediction of success, while others look into a minimalistic approach to launching the product. No matter what, research agrees that the business bottom line is that the success of a new product determines the company rankings in the marketplace (Rajagopal, 2008).

The criteria for success are important for companies to consider. In order to improve chances of having a product be successful, many factors should be evaluated. Measuring success in product development includes factors like market share, sales objectives, profit objectives, technical aspects, impact on the company, reputation of the company and timing of the project from the initial stages of development until the launch of the product (Brown and Eisenhart, 1995; Cooper, 1994; Clark, 1989). Some research has even categorized wellness and naturalness, convenience and product uses or values into the product definition. Each of these should be considered when developing a product so that there can be a 'harmony' of flavors that most consumers would want (Anon, 1999). These measurements of success were expanded upon to identify more specific areas including market form, marketing, economic abilities, general competence and internal organization of process stages (Kristensen *et al.* 1998). Even though this research included more detail for increasing success, more direction was still needed to define specific tests or questions to perform at each step.

Defining the product is important in the product development cycle and has proven to increase success (Wilson, 1994). Having weak pre-set criteria could decrease the chance of success. Wilson (1989, p 14) identified the important steps in defining a product with 10 factors:

1. *strategic alignment*
2. *customer needs*
3. *competitive analysis*
4. *compliances*

5. *product positioning*
6. *select project priorities*
7. *identify technical and process risks*
8. *identify appropriate market channels*
9. *management leadership*
10. *human and financial resources*

If you skip portions of the cycle, then projects fall short of projections and fail. Hewlett-Packard corrected their criteria for developing products and improved on the strengths and weaknesses of the cross-functional teams to see products launched with more organization and increased sales (Wilson, 1994; Wilson, 1989).

Fourt and Woodlock (1960) identified what is important to improving measurements of sales volume as a predictor of success by adding in the variable of time where some products require more time from the initial purchase to the repeat purchase. Extra information about first time buyers and the repeat buyers could be separated out. If it was possible to keep all of the variables (such as price, distribution, and promotional money) constant this method would be reliable and easy to use. But, markets continue to grow and consumers continue to try new things expanding into international flavors and textures. Restricting the definition of success to just looking at market share means that the degrees of success and failure are being overlooked (Johnson and Tellis, 2008).

Fortuin *et al.* (2007) developed the Wageninger Innovation Assessment Tool (WIAT) to compare drives and barriers to innovation. This tool addresses the following factors as most common in successful and failure products: product superiority, proficiency of marketing and technology activities, protocol clear and defined, identify market potential and organizational

relations. They concluded that using historical data for successful and unsuccessful products can correctly predict success by identifying weak and strong points on currently running projects with calculated failure and success means (Fortuin *et al.* 2007).

Proper timing and season of a launch are also important for the product to succeed. New products that are introduced into the market are more successful when seasonal demands are considered (Rajagopal, 2008). If an introduction time does exist for the product, launching at that time will increase the chance of limiting the amount of time it takes for the consumer to become aware of the product (Wilson and Norton, 1989). When there are two products to be launched at the same time and one is higher quality than the other, simultaneous launches would allow any consumer to choose the product that they desire instead of making the consumers of the other product wait (Moorthy and Png, 1992).

Even though most of the previous testing has been conducted on the definition and process of the product and how the product performs in the market, some research also addresses talking directly to the consumer and really identifying what the consumer wants in the product being created. Involving the consumer early in the product development process will assure that all the previously discussed topics are guiding the product to the desired end-point, the needs of the consumer. Having consumer focused new product development will not only lead optimization of the product but will address the areas that will make for strong marketing of the product to the target group (Bogue *et al.* 2006).

There is a wide range of consumers that could possibly accept the product and understanding who those consumers are is difficult without knowing what to research for (Wansink, 2003). Take time in the product development process to focus on what the end-user desires are and concentrate solely on the consumer. Collect information on aspects that could

influence product acceptance or rejection including age, gender, frequency of product purchasing, users, nonusers and association of product to familiar product or experience (Tuorila *et al.* 1998; Pliner, 1982). If the project is on a completely new product there will be a lot of information to collect from scratch to gather everything necessary about the consumers (Krieg, 2004). Other times projects will be line extensions or expansions targeting consumers that information has already been collected on. These projects do not require as much time to collect information, but it is still important to make sure the project has the end-user in mind to keep development of the product focused on the consumer (Braghieri *et al.* 2009; Ohr, 2001). The challenge is being able to consider the number of requirements that need to be collected from the consumer and having the right balance of information being collected to advance product development (Krieg, 2004; Ohr, 2001). No matter what, when evaluating consumers, they are very different and they give preference information on the product that sometimes can be unreasonable to develop (Wansink, 2003; Sidel *et al.* 1981).

Enhancing acceptance of new foods is important and should be encouraged. This includes effects of packaging, appearance and information on the product (Tuorila *et al.* 1998). Being able to recognize what the consumer needs is essential in their acceptance of the product (Rajagopal, 2008; Bogue *et al.* 2006).

Market Prediction

Predicting whether or not a product will be successful in the marketplace is determined based on calculating risk (Anonymous, 2007). These risks include timing of launch, product price, competitors, marketing support (Chomka, 2003), focusing on the consumers wants and needs (Ottesen and Grønhaug, 2005) and adaptability to market changes. Since each individual product in the market is fighting for the consumer to choose it, then showing what advantages it

offers makes it stand out. For product development to know the advantages that a product has, there are two values that should be considered; tangible values, things that can be seen and touched, and intangible values, things from imagination that must be guessed (Vranesevic *et al.* 2004).

The intangible values are more difficult to determine since they are part of the consumers' subjective experience. For a product to succeed there must be short-term success where the product is initially evaluated and enjoyed by the consumer. This short-term success must take place before long-term success, consumer loyalty, can be obtained. Superior production of products intangible values is necessary to retain customers. Typically the value that attracted the customer in the first place will continue to bring them back (Amadiou and Viviani, 2010). The construction of intangible values includes communicating with consumers through advertising, pre-purchasing, purchasing and post-purchasing process. The following list includes possible ways to observe and influence intangible values:

- Brand signifies the reputation of a company and is capable of contributing to the strength of the company. Brand also can contribute to the favoritism of the product by the consumers' unique product associations (Orth and De Marchi, 2007).
- Design or appearance of a product can impact initial purchasing because of the way the consumer sees the product. This can be influenced by clean labeling, simplicity (Anon, 2009) or health-related claims and information (Chiou *et al.* 2009).
- Advertising allows consumers to know a product is in the marketplace that could be beneficial to them. Direct marketing to potential consumers can help develop niches for the product as well as gain market share by creating consumer needs for the product (Buhr, 2004).
- Word of mouth is when consumers like or dislike a product and tell others about it. If there is an interest in foods for any reason (i.e. health such as heart healthy, omega-3 fatty acids, etc.) consumers will stimulate the product by expressing to other consumers to try the product (Heller, 2006).

Tangible values are influenced by the properties of the product and make it easier for the consumer to evaluate. Flavor, texture and aroma of products are taken into consideration as perceived value of the product is determined by the consumer (Vranesevic *et al.* 2004). The fundamental part of perceived value is perceived quality (Magnusson and Hursti, 2002; Santos, 2002). For example, if a company offers bad quality goods, then they will not be able to achieve high prices for the product. However, if a company sells a product at a high price, then consumers expect the product to be of high quality. This high quality includes all aspects of the product including the technical aspects, such as the physical properties (Vranesevic *et al.* 2004). Being able to offer high technical value and superior products along with support of advertising will attract and retain consumers (Sijtsema *et al.* 2009).

Even though tangible values are easy to measure by the consumer, they do not convert into product development that easily (Sijtsema *et al.* 2009; Vranesevic *et al.* 2004). Since it is important to have a consumer-oriented product development, talking to the consumers will gain insight into what they want; however, there is not a straight-forward translation from consumers to product development. There is a multi-tasking step that must take place to transform consumer terminology into product attributes that developers understand and can make changes on. This multi-level step involves sensory knowledge because the process may not be the same for all products or categories. When the product development process moves into focusing on the tangible terms, the information gains greater potential for being reliable and begins to create a more complete product. Even though tangible values involve knowing consumers wants and needs for the product, consumers can only tell their preferences (Stone and Sidel, 2004; Kramer, 1980; Moriarty, 1966). The most beneficial way to evaluate tangible values is through

measuring the differences between product quality (flavor, texture, appearance and aroma) using difference sensory methods (Sijtsema *et al.* 2009; Hart *et al.* 2003)

Launching products with both the tangible and intangible values known will reduce the amount of risk involved. Launching without this knowledge could explain why products don't succeed (Chomka, 2003). The relationships between these values separate competitive products from each other and develop the market into a strenuous place for new products to be successful (Siró *et al.* 2008).

Sensory Methodology

Consumers may give the guidelines necessary for a product to be successful, but optimizing these needs is difficult for the consumer to do. Descriptive panels can give more insight into how to optimize attributes after the consumer has identified what they want. Descriptive sensory testing is the most sophisticated tool in the sensory toolbox by providing “quantitative descriptions” of products based on trained panelists (Stone and Sidel, 2004; Lawless and Heyman, 1999). Product development benefits from descriptive testing because it focuses on the product variables that are identified as different (or similar) among the target product. This detection and description of sensory attributes can relate to specific ingredients or process variables that are important to consumer acceptability (Meilgaard *et al.* 2007; Stone and Sidel, 2004).

The flavor profile was developed with the idea of creating a distinctive measurement for attributes in a product using a trained panel. This method is specific to flavor and aroma attributes that are found in the product. The attributes that are detected are defined and then a measurement of intensity is given. This method also includes measuring amplitude (an overall impression of the product), order of appearance of the attributes and aftertaste measurements of

the product (Meilgaard *et al.* 2007; Stone and Sidel, 2004; Lawless and Heyman, 1999; Keane, 1992; Caul, 1957; Cairncross and Sjöström, 1950).

There are three other descriptive methods that need to be addressed: the texture profile method, quantitative descriptive analysis (QDA) method and the Spectrum descriptive analysis method. The texture profile method focuses on measuring the mechanical and geometric attributes as well as attributes related to moisture and fat content of the product (Muñoz *et al.* 1992). The QDA method measures a complete list of sensory attributes that are based on panelists' perceptions, order of occurrence of the attributes and relative intensity measurements of the attributes (Stone, 1992). The Spectrum method provides descriptions on the major sensory categories with descriptions of the attributes within the category and the intensity for each attribute (Muñoz and Civille, 1992).

Many researchers have adapted these descriptive methods and created lexicons to include specific attributes for categories such as green tea (Lee and Chambers, 2007), nuts (Civille *et al.* 2010; Johnsen *et al.* 1988), fresh and processed tomatoes (Hongsoongnern and Chambers, 2008), dairy products (Oupadissakoon *et al.* 2009; Thompson *et al.* 2009; Coggins *et al.* 2008), soybeans (Krinsky *et al.* 2006) and personal products (Dooley *et al.* 2009, Hightower and Chambers, 2009; Civille and Dus, 1991). These lexicons create great knowledge for future researchers to start their own research from. Each lexicon provides attributes and definitions for the category and the modified method that was used to create the information.

Even though the flavor method is important because of the assessment of the attributes, it is also critical to properly select and train the panelists. Selection of panelists includes a variety of tests to determine their discriminant abilities. Caul (1957) identified 4 areas to test:

- Basic tastes to determine ability to differentiate between basic tastes (sweet, sour, salty and bitter).

- Odor perception test to assess the ability of the panelist to perceive different odors at different levels.
- Odor recognition is performed to determine the number of odors the person can identify ranging from everyday odors to those less frequently encountered.
- Personal interview is necessary to learn about the potential panelists' interests, personality, experience and past performance.

Researchers have expanded on the requirements for selecting panelists. Keane (1992) expanded upon the tests previously identified by including a test to assess the ability to make independent choices, rank products by intensity and arrange products by amplitude and interactions within the potential group.

Once the panelists have been selected, they are then trained. Typically, for flavor profile, the panelists are trained daily for six months to a year in order to accurately train the panel on the profiling procedure and technique including the aspects of smelling, theories of tasting and other concepts (Lawless and Heyman, 1999; Cairncross and Sjöström, 1950). Training for other descriptive tests does not require as much time. The QDA method requires about two weeks for training on developing terminology, definitions and evaluation procedures (Stone, 1992). The texture profile trains panelists for about four to six months on texture definitions, evaluation procedures and reference scales (Muñoz *et al.* 1992). The Spectrum method trains for three to four months on basic principles of sensory and descriptive analysis while developing terminology, using references and selecting evaluation techniques (Muñoz and Civille, 1992). Even though the panelists are trained for different amounts of time, the overall goal is to train the panelists to fully understand the terms and apply the procedures in the same way (Meilgaard *et al.* 2007; Stone and Sidel, 2004; Lawless and Heyman, 1999).

Research has shown that length of time spent training a panel can influence testing results from the panel. Chambers *et al.* (2004) found that when panels increase the number of hours (4 h, 60 h, 120 h) for training, there is improved panel performance by reducing variability in the results of the project. Along these same lines, when training increases, the number of attributes that the panelist can evaluate increases (Del Castillo *et al.* 2008; Wolters and Allchurch, 1994).

The key to the flavor profile is the panel leader, the person responsible for conducting and recording information during the panel. After the panel is complete, the panel leader also compiles the data and interprets it for use. Being a panel leader is a full time job with the organizing and directing of the panel. He or she sits in with the panel and acts as a link between the developers and the panel. The panel leader can also be a member of the panel or not, but either way, they should not overrate their importance on the panel (Stone and Sidel, 2004; Keane, 1992; Caul, 1957). The QDA, Spectrum and texture profiles all typically use a sensory professional as a panel leader; however, the Spectrum method can use a panelist that has been trained to be a leader (Muñoz *et al.* 1992; Muñoz and Civille, 1992; Stone, 1992).

There are many sensory scales that are used for descriptive testing methods. There are three main types of scales (Meilgaard *et al.* 2007; Lawless and Heyman, 1999):

- Category scales that use words or numbers with equal intervals between the categories
- Line scales that use a line that is 6 in or 15 cm long where the panelist makes a mark on the line to identify the intensity
- Magnitude estimate scales where the intensity is based on the number given to the first sample and then all other samples are a proportion of that number

The flavor profile originally used simple category scale for measuring attributes. The intensity scale ranged from 0-3 where 0 is very low, 1 is low, 2 is medium, 3 is high (Caul,

1957). However, through the years of methods evolving, several of the methods have changed or have adaptations that use different scales. The part of measuring intensities that has not changed over the years is whether or not the methods are consensus or individual assessments. The flavor and texture profiles are a consensus method where the panelists come to an agreement of the intensity for each attribute, which is much easier to do with methods because the panelists are trained for a longer period of time so the panelists are more likely to be measuring more consistently (Keane, 1992; Muñoz and Civille, 1992). The Spectrum and QDA methods are individual scores that require more statistical analysis to report results (Meilgaard *et al.* 2007; Lawless and Heyman, 1999; Muñoz *et al.* 1992; Stone, 1992).

Product development can use these descriptive testing methods to assist with the wide range of prototypes that are developed throughout the project. Having information on the differences and similarities between prototypes can guide development efforts in the necessary path. Properly using sensory could increase the chance of success by minimize the risk of improperly collecting data and creating false results (Sidel *et al.* 1981).

Salivation

Chewing a food product not only helps to break the product down, but it releases the compounds necessary for consumers to determine if they like the product (Harthoorn *et al.* 2009). During mastication, the fluid in saliva during salivation helps to release the volatile compounds that assist the consumer to make an overall perception of the flavor (van Ruth *et al.* 2001; Harrison, 1998). Understanding how salivation relates to consumer liking may be important for product developers to make changes on products. Using trained panelists to evaluate salivation allows for more time to teach the technique, control timing of the evaluations

and see salivary flow differences compared to baseline measurements (Bramescio and Setser, 1990).

Salivation is the mixture of food and saliva during the mastication process in the mouth. As food products are chewed to the point of swallow saliva is incorporated into the bolus that is being formed (Bourne, 2004; Smith, 2004). Salivation is important in food perception due to the secretion from salivary glands that allow taste to be perceived (Harthoorn *et al.* 2009). Since saliva is necessary to protect the oral tissues in the mouth and begins the digestive process it is interesting how it is influenced by the food being consumed (Orchardson, 2001).

Many methods have been created for measuring salivation. Navazesh and Christensen (1982) began with four salivary collection methods: draining, spitting, suction and swab. The draining method of collecting salivation requires saliva to drain out, between parted lips, through a funnel and into a test tube. When whole milk salivation was collected from likers and non-likers of flavored milk consumers, there was no different in average salivary flow rate, but when compared to water salivation, the non-likers had higher average salivation rates when consuming the milk (Porubcan and Vickers, 2005). Differences were also found between Ghanaians and US consumers for mean resting salivary flow rates. When the same consumers were stimulated by viewing and smelling food products both sets of consumers increased salivation rates, with no significant difference (Lokko *et al.* 2004).

The spitting method is similar to the draining method except that saliva was collected in the mouth, with the lips closed, and was expectorated at the end of the trial (Navazesh and Christensen, 1982). When consumers (18-85 years) were stimulated with basic taste solutions at different threshold levels, there were increased levels of salivation for all ages groups except for elderly (ages 60-85), where caffeine, quinine and MSG flavor enhancer had decreased salivation

for each increasing solution (Mojet *et al.* 2005). Due to changes in texture and aroma, 10% whey protein gels increased salivation production over 4% whey protein gel products for panelists with limited training (Mestres *et al.* 2006). When evaluating caffeine and beer consumers, Tanimura and Mattes (1993) did detect differences in thresholds caffeine, iso-alpha acids and quinine compounds, however, there were no salivary differences among compounds. When studying astringent solutions, consumers that were astringent sensitive had significantly higher salivation (Dinnella *et al.* 2009).

The suction method uses a plastic dental saliva ejector tip that is placed under the tongue, as saliva is secreted it is collected in a test tube. At the end of the trial the tip was moved around the mouth in a pattern to collect residual saliva (Navazesh and Christensen, 1982). When positioning the suction directly over the parotid gland data can be directly recorded from an instantaneous flow meter (Anderson and Hector, 1987). Studies can determine peak salivary flow rates with the suction method which was not accomplished with the other methods. When subjects were given different doses of MSG, it was found that peak salivation and salivary flow rate were dependent on the dose of sodium ions in the MSG (Hodson and Linden, 2006). If air was delivered into the mouth through a tube and the salivation was collected through suction from the parotid gland it was found that there were no differences from the resting rating to different amounts of air being put into the mouth. These results show the importance of knowing the baseline salivation for each participant (Guest *et al.* 2006). It has also been found that pH of the saliva can be affected by the amount of salivation. There was a slower increase in salivation instantaneous flow when the pH of the saliva was higher, this linear relationship occurred when a stimulation had been given to the consumer (Neyraud *et al.* 2009).

In the swab method subjects are given three dental cotton rolls and asked to place them in the mouth, one roll under the tongue, and the other two on the sides of the mouth between the cheek and teeth in the upper section of the mouth (Navazesh and Christensen, 1982). This technique was a variation (in the time that swabs were in the mouth) of the one created by Peck (1959) that was named SHP for Stongin, Hinsie and Peck. When the swab method was used with high calorie and low calorie consumers there was no significant difference in habituation between the groups, but, the salivation rate was decreasing for all chocolate and lemon flavored gelatin products during the trial (Epstein *et al.* 1993). Also with participants 8-12 years old, there were no significant salivation changes for the first eight trials, all showing familiar food products. However, when a new food was introduced, there was a significant increase in salivation (Epstein *et al.* 2003). Epstein *et al.* (1996) found differences in salivation between obese and nonobese subjects where salivation response decreased more for the nonobese group with repeated presentation of food cues. Temple *et al.* (2006) found a significant relationship between motivated responding and salivation in children that were shown cheeseburgers and french fries.

Frequency of swallowing has been used as a non invasive way of counting peaks in the electromyographic activity. This method allowed for timing of salivary response to be monitored, but no measurement taken (Nederkoorn *et al.* 2001). Even with this modified method of collecting salivation, the reviewed methods did not look into ways to collect salivation information from the consumers or panelists without collecting any saliva from the mouth.

Summary

Research relating to market success and market prediction of new products is characterized by the different approaches that can be taken. The majority of the methods require

multiple steps to be considered through the project to help keep the end-user, the consumer, in mind. Beginning steps focus on developing the knowledge necessary for the product to be created, which can include market assessments to determine what is already in the market, who the consumer is, what their needs and wants are and the competitors. As development of the product starts, it is important to have already collected as much information for the project as possible so that the focus can be on a successful product. It is essential to use sensory methods to talk to the consumer and then use descriptive testing as guidance through product development. This descriptive guidance during product development will increase the knowledge of the product by identifying similarities and differences between the products that can be used to guide changes that may need to be made. The previous research greatly identified the areas to consider when developing new products; however, there was little direction as to the methodology that should be considered. Addressing the types of questions that should be answered prior to a launch and statistically modeling of sensory tests that could lead to a successful product would be helpful.

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***CHAPTER 2 - A comparison of methods for
measuring salivation to food products***

"SUCCESS DOESN'T COME TO YOU, YOU GO TO IT." - MARYA COLLINS

Abstract

Salivation is important for mastication and the release of flavors. Production of saliva is known to differ when foods of various textures are eaten. Research has shown that there is a relationship between consumer liking and salivation. However, questions have been raised as to whether salivation can differ because of flavor changes in products. This first phase of this study measured salivation for four food products with large variation in texture: potato chips, cookies, chewing gum, and gummi candy. Salivation was collected using three methods: spitting, cotton roll absorption, and sensory scaling. All methods gave the same differences in salivation among the products, but the spit method gave slightly lower variability or was easier to use. Thus, the spit method was chosen for use to compare salivation of variously flavored products with the same texture: flavored potato chips. Significant differences in salivation among flavors of the chips show that salivation is not just a function of chewing, but also can be induced by changing flavor.

Introduction

Salivation is the initial process of food digestion and activates the release of flavor (Pionnier *et al.* 2004). Saliva has a complex role: mixing with food to form a bolus for swallowing (Bourne, 2004; Smith, 2004), minimizing or increasing impact of certain flavors (Terpstra *et al.* 2009), protecting the oral tissues in the mouth and beginning the digestive process (Orchardson, 2001).

Because the amount of saliva can change depending on food products, saliva has been collected for testing in numerous different ways. Navazesh and Christensen (1982) compared four salivary collection methods: draining, spitting, suction and swab. The draining method of collecting salivation requires saliva to drain out, between parted lips, through a funnel and into a test tube. Using the draining method, Porubcan and Vickers (2005) found no significant differences between the salivation of consumers that liked and did not like the aftertaste of whole milk. Also using the draining method Lokko *et al.* (2004) found resting salivation flow rates to be significantly higher for Ghanaians compared to US consumers when presented with visuals and aromas of foods.

The spit method is similar to the draining method except that saliva is collected in the mouth, with the lips closed, and is expectorated at the end of the trial (Navazesh and Christensen, 1982). Mestres *et al.* (2006) used the spit method and found that 10% whey protein gel can increase saliva production over a 4% whey protein gel because of texture and aroma differences between the two products. The spit method has also been used to compare the relationship of decreasing salivation pH with increasing astringency (Siebert and Euzen, 2008).

The suction method uses a plastic dental saliva ejector tip that is placed under the tongue and as saliva is secreted it is collected in a test tube. At the end of the trial the tip is moved

around the mouth in a pattern to collect residual saliva (Navazesh and Christensen, 1982). Few studies were found using this method perhaps because it requires specialized equipment and also because it does not allow the natural mixing of the saliva and food, which could impact the rate or amount of salivary flow.

In the swab method, subjects are given three dental cotton rolls and asked to place them in the mouth, one roll under the tongue, and the other two on the sides of the mouth between the cheek and teeth in the upper section of the mouth (Navazesh and Christensen, 1982). This technique was a variation of the one created by Peck (1959) that was named SHP for Stongin, Hinsie and Peck. Epstein *et al.* (1993) found no significant difference in habituation between groups of high calorie and low calorie consumers that ate lemon and chocolate flavored gelatin. Epstein *et al.* (1996) found differences in salivation between obese and nonobese subjects; the salivation response decreased more for the nonobese group with repeated presentation of food cues. Temple *et al.* (2006) found that for children, salivation increased when presented with food cues such as cheeseburgers and french fries.

It is known that salivation helps change textures of products through chewing to produce a bolus in order to swallow the product (Bourne, 2004; Smith, 2004). Chewing also releases the flavor compounds to help consumers determine whether they like products. Harthoorn *et al.* (2009) indicated that fluid in saliva is what makes salivation important in food perception for consumers. Because overall perception of flavor is a combination of volatile and nonvolatile compounds released during oral manipulation as products mix with saliva, understanding the mechanisms of this release of volatile compounds can aid in developing new products (van Ruth *et al.* 2001; Harrison, 1998). However, it is not clear from studies whether flavor alone can impact salivation. If it can, then being able to identify flavors that can increase or decrease

salivation could transform and speed up product development stages when researchers suspect that a specific type of response is needed.

Although different salivation testing techniques are available, few studies have compared the methods and no studies were found that compared a sensory measure of salivation to other techniques. Thus the objectives of this research were 1) to compare whether differences exist in “salivation” among various products using three methods for measuring salivation, and 2) to use one of the methods to determine if differences in salivation are found when only flavor changes are made to a product.

Materials and Methods

Phase I

The first phase was to compare methods for measuring salivation and to identify one method that would be used in further testing with descriptive sensory panelists.

Products

Four commercial, dry snack products were chosen for testing based on their representation of a variety of snack food textures: Lays’ Sour Cream and Onion Potato Chips, Keebler Chips Deluxe Soft ‘n Chewy Chocolate Chip Cookies, Extra Long Lasting Winterfresh Gum, and Haribo Gold-Bears Gummi Candy. All the products were purchased at the same time from a supermarket. Products were selected from preliminary research based on the perceived production of different amounts of salivation during chewing.

A new package of each product was opened each day of testing to assure the freshness of the products being tested. Sample amounts being chewed were different based on the product: chips, 1.00 g \pm 0.05 g; cookies (approximately $\frac{1}{4}$ of the cookie), 4.05 g \pm 0.5 g; one stick of gum, 2.50 g \pm 0.1 g; or one green gummy bear, 2.35 g \pm 0.05 g. All products were served as

purchased. A separate sample was used for each method and each of the three repeated evaluations. Samples were placed in small foam cups labeled with a 3-digit code and the panelist numbers. All samples were served at room temperature.

Panelists

A panel consisting of seven highly trained descriptive panelists from the Sensory Analysis Center at Kansas State University evaluated the samples over multiple days. The professional panelists have completed 120 hours of general training and have had an average of more than 2,000 hours of testing experience. Before testing, all panelists were trained on the salivation methods that would be used in the evaluations.

Testing Procedures

Three different types of methods were used to determine differences in salivation: spit, sensory scale, and cotton roll. For each of the testing procedures the measure of salivation and qualitative comments from the panelists were collected to help in determining which method would be used in further testing.

Spit

A foam cup was pre-weighed, the sample was weighed, and a combined weight of the cup and sample was recorded. Panelists were served the pre-weighed sample in the foam cup with a three digit code and panelist number. Panelists took a drink of water to cleanse the mouth, chewed the sample until the point of swallow and then expectorated everything from inside the mouth into the sample cup. Then panelists rinsed their mouths using 10 mL of premeasured water and expectorated it into the same cup. The cup was covered with a lid to prevent evaporation. For weighing, the lid was removed; the cup weighed; and the weight of the cup, product, and water was subtracted from the total weight to give a measurement weight of saliva.

Cotton Rolls

For cotton roll absorption, small foam cups and plastic zippered bags were labeled with the appropriate 3-digit codes and panelist numbers. The product samples were pre-weighed and placed in the cups. The plastic bags were pre-weighed, and two full size dental cotton rolls (#2-medium, sterile, TIDI Products, LLC, Neenah, WI, USA) and a ½ cotton roll were weighed and placed into the plastic bag. Panelists were served the pre-weighed food sample in the foam cup, put on plastic gloves, took a drink of water, and placed the pre-weighed cotton rolls from the plastic bag into their mouths. One full roll was placed on each side of the mouth between the cheek and lower gum; the half roll was placed under the tongue. The food sample was then placed into the mouth and chewed until the point of swallow. The cotton rolls and remaining food mass was expectorated into a plastic bag for weighing. Panelists were allowed to use their fingers, if needed, to remove the cotton rolls. For weighing, the weight of the plastic bag with the cotton rolls and expectorated product were subtracted from the total weight to give a measurement weight of saliva.

Sensory Scale

For the sensory scale comparison, small foam cups were labeled with the appropriate 3-digit codes and panelist numbers. The sample was pre-weighed and recorded. Panelists were served the pre-weighed sample in the cup; panelists took a drink of water to cleanse the palate and chewed the sample until point of swallow then expectorated or swallowed. Panelists rated the amount of salivation on a scale from 0 being no perceived salivation to 15 being extremely high perceived salivation. Scale measurements were made for the amount of salivation during the chewing process at three time points: a) initially when the sample was put into mouth, b) the highest amount of salivation, and c) at the end just prior to swallowing. The maximum salivation and the end just prior to swallowing could be the same point.

Data Analysis

Analysis of variance using a general linear model (PROC GLM in SAS[®] 9.2, Cary, NC, USA) was performed for each method to determine if a significant difference existed among the salivation measurements for the food samples. Means were determined for each of the food samples for each method and compared using the least significant difference (Fisher's LSD) at $P < 0.05$.

Since it is likely that there will be some bias in each of the methods because of the natural reaction of swallowing while chewing the product or to particles being left in the mouth (Wright *et al.* 2003), actual measurements were not compared to each other, but were compared based on differences found among products within each method. Additionally, qualitative comments from the panelists were compiled and used to give added information, when appropriate.

Phase II

Phase II was to determine if the selected method from Phase I could be used to differentiate between salivation based on flavor changes alone.

Products

Eight flavored potato chips were chosen for testing based on variability in the chip category. The flavors selected were all different, but to ensure some similarity they were all animal-based product flavors denoted as: Barbecue, Cheese, Chicken, Grilled, Seafood, Ham 1, Ham 2, and Brown Sweet Beef. All flavors were applied to a fried potato chip base using standard industrial processing methods. For the test, chips were selected that weighed $1.0 \text{ g} \pm 0.05 \text{ g}$. A new bag of product was opened each day to assure freshness of products being tested. A separate sample was used for each of the three replicate evaluations. All samples were served at room temperature.

Panelists

The same panel, consisting of seven highly trained descriptive panelists, evaluated the products in the second phase of this research.

Testing Procedures

Samples were evaluated using the procedures for the spit method from Phase I. Samples were placed in small foam cups labeled with a 3-digit code and the panelist numbers.

Data Analysis

Data was analyzed in the same way as the previous testing. Analysis of variance using PROC GLM was conducted to determine if a significant difference existed between the samples. Means were determined for each sample and compared using the Fisher's LSD at 0.05.

Results and Discussion

Phase I

Table 2.1 illustrates that the three methods for salivation measurement gave the same basic differences between the four products. The gum had higher ($p < 0.05$) measures of salivation, regardless of the method, than the gummy bear, which was higher than the chips and cookie, which were not significantly different from each other for any of the methods. This would suggest that each of these methods could be used for testing effects of products on salivation.

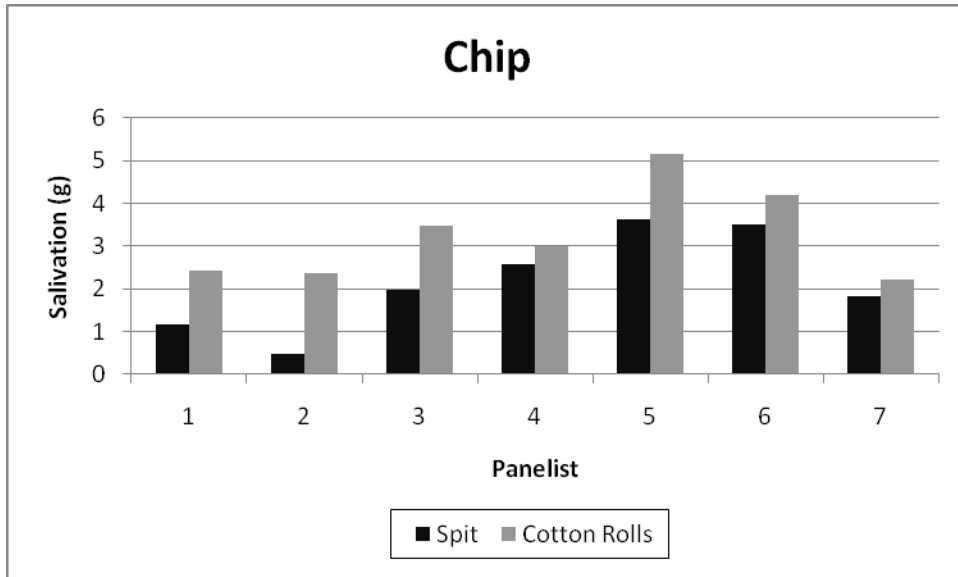
Table 2.1 Salivation means of different testing methods for various food products

	Spit (grams)¹	Cotton Rolls (grams)¹	Sensory Scale (amount: 0-15)¹
Gum	4.92 a	5.55 a	14.90 a
Gummy bear	3.32 b	4.80 b	13.98 b
Chips	2.16 c	3.25 c	10.10 c
Cookie	1.93 c	2.99 c	9.95 c
LSD ²	0.56	0.35	0.55
Mean CV ³	29.02	13.38	7.22

¹ Means with same letter within column are not significantly different at the 95% confidence level.
² LSD = Least Significant Difference; the smallest difference between two rank sums that would result in a significant difference at the 95% confidence level.
³ Mean CV = the mean of the Coefficients of Variation for each of the panelists for each of the products. This average accounts for variation within an individual panelist for a particular product type without including variations among panelists.

When evaluating different people and the amount of salivation it is important to take note of the differences in the amount of salivation for each panelist individually. Figure 2.1 is an example of how this study has differences in the amount of salivation between panelists. Figure 2.1 shows the spit and cotton ball methods for all seven panelists and the mean salivation amount for evaluating chips in Phase 1. This figure shows panelist 5 produces the most amount of salivation across the panelists for the cotton rolls method. Panelist 2 has a very low amount of salivation for the spit method compare to the other panelists, but does not seem to be as different in the cotton rolls method. This salivation difference among individuals is consistent with other studies; inter-individual differences within whey protein gel salivation (Mestres *et al.* 2006) and lower baseline measurements for obese panelists (Epstein *et al.* 1996). Bramescio and Setser (1996) also found individual differences among individuals that were smokers or had diet-induced deprivation.

Figure 2.1 Chip mean salivation scores for spit and cotton roll methods for all panelists



Further analysis of the mean coefficients of variation suggests that the cotton roll procedure gave data that was more variable within an individual panelist, suggesting it may not be the best method. Additionally, qualitative comments from the panelists were quite negative for this procedure. They indicated it was difficult to chew properly and that the cotton rolls absorbed the saliva needed to fully masticate the products. The higher weight for the saliva found using the cotton roll procedure could indicate that more saliva was produced as the mouth detected dryness because the saliva was being absorbed by the cotton rolls.

Because all methods showed similar mean results, it is possible to use any of the methods and get reasonable answers when comparing large differences. However, in order to test if potential smaller differences (i.e. differences in flavor only) additional considerations were needed. The easiest method to execute would be the sensory scale because there is little preparation required (not as much weighing) and little time needed after the test (no additional weighing) meaning less total staff time. One problem with the sensory scale is that more training

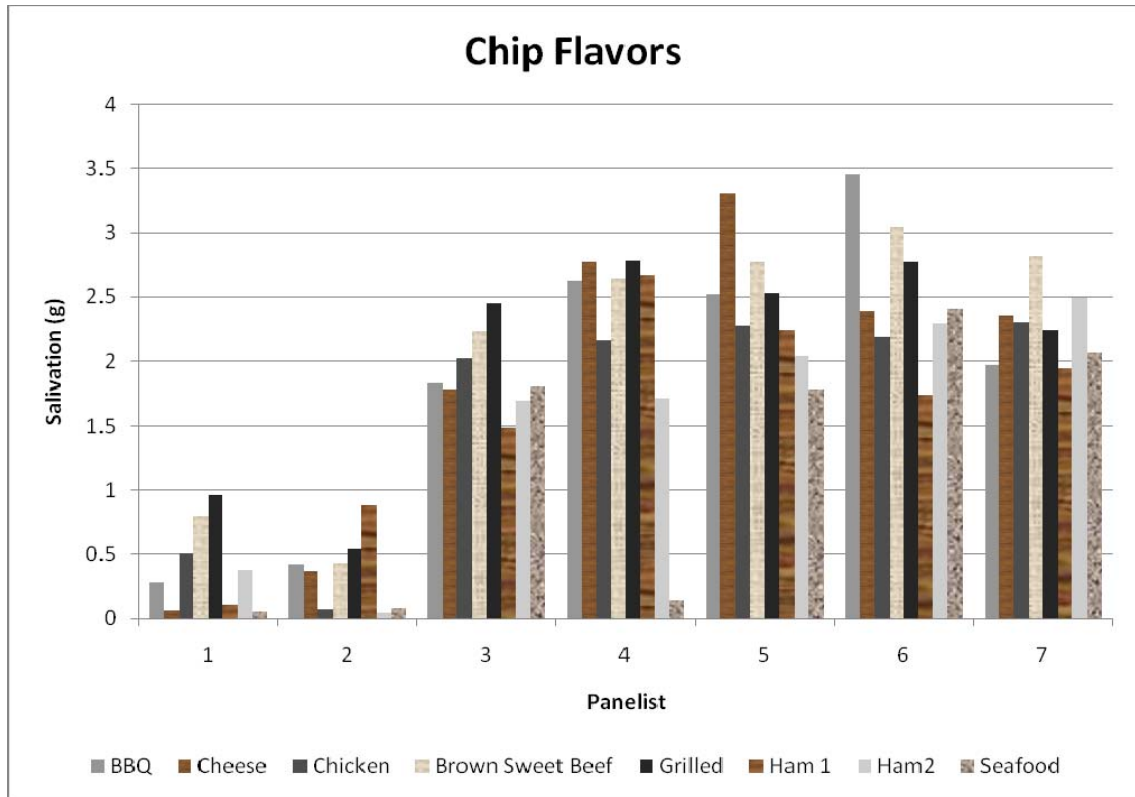
is needed with the panelists in order to assure that they understand how to use the salivation scale. This was surprisingly difficult for some of the panelists used in this study, even though they were well trained. Some panelists had difficulty translating a sense of volume and wetness into a score for “amount or intensity of salivation”. It is unknown whether other panelists who are less trained would have similar or more difficulties, but there is no reason to believe they would find it easier. Interestingly, the panelists had a stated preference for the spit method because it was the easiest for them to use and required little instruction to use the technique. Although panelists do not determine the method to use, their input can be of value when deciding among alternatives that are equally appropriate.

Clearly any of the methods could be used in further work. However, in this case, it appears that the combination of quantitative and qualitative information suggests that the spit method is a reasonable method for comparing further differences.

Phase II

The eight flavors of potato chips were tested using the spit evaluation procedure from Phase I. Two panelists had lower salivation than other panelists (Figure 2.2). The decision was made to continue using all of the panelists noting that there appears to be a difference between the panelists. Bramesco and Setser (1996) classified panelists as high, medium and low using a different salivation procedure, based on the information found, it seems that the panelists from this study would be classified as low and moderate (Navazesh and Christensen, 1982).

Figure 2.2 Chip mean salivation scores for flavors and panelists



Differences were found in salivation based on flavoring alone (Table 2.2). The brown sweet beefy and grilled chips had significantly higher salivation than the chicken, ham 1, ham 2, and seafood. The barbeque chip was significantly higher in salivation than the ham 2, and seafood.

Table 2.2. Salivation means scores for chip flavors

Product	Mean¹ (grams)
Brown Sweet	2.10 a
Grilled	2.04 a
BBQ	1.87 ab
Cheese	1.86 abc
Chicken	1.65 bc
Ham 1	1.58 bc
Ham 2	1.52 c
Seafood	1.14 d
LSD ²	0.34

¹ Means with same letter are not significantly different at the 95% confidence level.

² LSD = Least Significant Difference; the smallest difference between two mean values that would result in a significant difference at the 95% confidence level.

Overall the brown sweet beefy chip resulted in nearly a 65% greater salivation measurement than the seafood chip. In addition, seafood is significantly lower in salivation than all other samples which is particularly interesting because seafood is not a typical snack food flavor for U.S. consumer. Although in the past consumer tests of seafood flavored snack foods have been conducted, the flavor is not found in wide distribution and does not seem to have wide appeal as a snack food flavor for U.S. consumers. Although it is impossible to determine from this data whether low salivation is indicative of a simple lack of familiarity with the flavor or a more complex issue of acceptance of the flavor, the data suggest that salivation should be studied further as an early research and development tool for assessing potential market place appeal.

Conclusions

Salivation can change even though only the flavor of the product (in this case potato chips) varies. This finding is important because past studies have shown chewing releases flavor components necessary to determine consumer liking (Bourne, 2004). Since this research shows that there are differences between flavors based on salivation, then further testing could be done to determine if changes in salivation could relate to consumer liking. The spit method conclusions did determine flavor differences and it requires the least amount of training of the methods tested, so this method possibly could even be used by consumers. Having consumer liking measurements and collected salivation amounts for products could explain further the relationships between salivation and flavor.

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***CHAPTER 3 - Predicting success for new flavors
with information known before launch: A flavored
snack food case study***

"SUCCESS IS TO BE MEASURED NOT SO MUCH BY THE POSITION THAT ONE HAS REACHED IN LIFE AS BY THE OBSTACLES WHICH HE HAS OVERCOME WHILE TRYING TO SUCCEED" - BOOKER T. WASHINGTON

Abstract

Success in the marketplace is the goal of every product launched, but the survival rate can be low in the first year. Knowing what market data to collect that could predict success before launching a product would be valuable to companies. Thus, the objective of this study was to determine whether success of new line extensions for a multi-flavored snack product available in the international marketplace could be predicted from information available before launch. One hundred two unique flavors that met acceptance hurdles established by the company and were introduced in the marketplace were selected from 15 countries and further narrowed to 63 flavors, based on launch information. Staff in each country completed a questionnaire for each product that included questions related to the sensory aspects of the flavors such as authenticity, familiarity, and capturing current trends; packaging issues and market place issues such as product competition and pricing, all of which were known before launch. A discriminant function analysis was conducted that correctly identified 75.8% of the successful flavored snack products as successful and 66.7% of the unsuccessful products as unsuccessful. Stepwise comparison was used to determine the variables necessary to correctly categorize the snack products. Criteria such as being a trendy flavor, new to the category, being based on foods from restaurants or traditional foods was helpful for this product category to assist in predicting market success.

Introduction

Predicting success in the market prior to a launch is difficult. Designing a strategy to allow continuous introduction of new products into the marketplace before competitors will increase the chance of success (Fortuin *et al.* 2007). New products can come from different paths to the marketplace including new concepts, new raw materials, line extensions, reviving old products and targeting a new audience (Hanchate, 2006). As these new products are created in the innovation phase, the decision making processes are used to assist with making sure the product is headed towards a successful launch (Jones and Jew, 2007). These processes include working in cross-functional teams with other areas contributing to the development of the product (Wilson, 1994), creating as many different innovative ideas as possible (Jones and Jew, 2007), comprehensive market assessment and determining what the consumer wants (Bogue *et al.* 2006).

When completing a comprehensive market assessment it is critical to evaluate 10 factors to identify the definition of the product and improve the chance of success. Wilson (1989, p 14) identified these factors as: “*strategic alignment, customer need, competitive analysis, compliances, product positioning, select project priorities, identify technical and process risks, identify appropriate market channels, management leadership, and human and financial resources.*” For Hewlett-Packard (HP), if any of these portions were skipped they found projects fell short of projections and failed in the marketplace. When the cross-functional teams worked together and these factors were considered and agreed upon, however, HP saw more organized launches (Wilson, 1994).

As product ideas are developed and continue into the product development life cycle, it is necessary that all preliminary information from the consumer marketplace already be collected.

Starting the product development phase without gathering knowledge of what needs the product must satisfy will not lead to a project focused on success (Buisson, 1995). The biggest challenge is the tedious job of collecting all the necessary information from the consumer marketplace and knowing which requirements are the most critical to consumers for success. Because consumer needs often change slowly, it is possible to collect the necessary information from the consumer and then only update or confirm the information previously collected (Krieg, 2004).

Predicting whether or not a product will be successful in the marketplace is determined based on calculating risk (Anonymous, 2007). These risks include timing of launch, product price, competitors, marketing support (Chomka, 2003), focus on consumers wants and needs (Ottesen and Grønhaug, 2005), and adaptability to market changes. Creating flavor fusions in new markets using export opportunities requires adaptability because the ethnic flavors may be familiar and acceptable in the country of origin, but may be unfamiliar to the new target country. In order to increase the chance of success it is important to learn about acceptable variables by product testing and looking at the product as part of the new country's daily life (Tuorila *et al.* 1998).

Timing of launch is also important to consider to reduce risk of failure. If an appropriate time or season does exist for the product (e.g. launch of white chocolate and cinnamon flavors at Christmas time coinciding with a movie release), then launching the product at that time will increase consumer awareness of the product (Watson, 2003; Wilson and Norton, 1989). Product pricing also is critical for success. Sometimes new products are priced higher or promoted as premium products in order to pay for the innovations used to create the product. Other times, companies will take a decrease in short-term profit to maintain a more reasonable price to encourage first time buyers to try the product (Rajagopal, 2008).

While it is known that keeping the end-user in mind will require staying in touch with the consumer through the whole project, it is sometimes difficult to do this, especially if there is not funding to support such extensive testing (Harmsen *et al.* 2000). If this is the case, looking at previously collected data or information that could be known prior to launch a product could lead to enhanced decision making. The objective of the present study, therefore, was to determine whether success could be predicted from information available before launch.

Materials and Methods

An international food manufacturer was contacted and agreed to provide product information for this study. The study was conducted using a flavored snack food available in many international markets. Conversations with product development and marketing teams in the company generated various options for market and product selection. Ultimately, a flavored snack food product made from a similar base product was selected because it is widely available in many international markets on all continents. Additional discussions related to market selection consisted of factors such as product development activities for the country (an active product development program for the country was needed), whether information would be readily available (i.e. markets with major recent staff turnover were excluded because new staff might be unable to provide some answers on past products), and market breadth (a wide range of countries was desired).

Countries and Products

For the present study 15 countries provided a list of successful and unsuccessful flavors launched in the past five years. Countries contacted to be included in the study were Argentina, Australia, Brazil, China, Egypt, India, Mexico, Poland, Russia, Spain, South Africa, Thailand,

Turkey, the United Kingdom, and the United States. Initial data were requested on three successful and three unsuccessful flavors from each of the countries. Some countries responded with more products than were requested while other responded with less. Each flavor was identified and classified by the country as either *successful*, having been in the market longer than one year, or *unsuccessful*, having been removed from the market in less than one year. To be included in the study, each product had to have met initial liking hurdles set by the international company, with local input, before launch. The products each country selected were to include only problems perceived as product-related rather than ones the company felt were unsuccessful because of in-market launch execution problems. Products introduced with minimal after launch support, products introduced with poor market timing, or ones intentionally introduced as seasonal are examples of launch execution problems. The following initial questions were asked to assure that all products were accurately chosen:

- Was this product successful or unsuccessful?
- Was the introduction and marketing of this product executed well?
- Where there any cost issues affecting the product (e.g. premium pricing)?
- Was the product released with appropriate after-market support?

Any product that was not introduced well into the market area, had cost issues or did not have appropriate market support was excluded from the study because the intent was to focus on product characteristics that were known before launch that could help determine longer-term (i.e. more than one year) success. There were 63 products selected for further evaluation on the full questionnaire.

Questionnaire Development

A questionnaire was developed to collect as much information as possible about the products that were launched into the marketplace. Figure 3.1 (at the end of the chapter) shows the questionnaire that was completed on each of the products in the study. It included multiple choice questions as well as yes-no items and 5-point scales to collect information on the products.

To assure that information was collected on market (e.g. in-market sales and competitive situation), product (e.g. liking, aftertaste and authenticity) and concept (e.g. purchase interest) data from the company, additional information that could be included in the questionnaire. Because each product was launched into the marketplace prior to the testing, actual data was collected on the performance in the marketplace. These are the categories used for the collection of market data:

- Product summary (SKU, target consumers, etc.)
- Time of launch and location
- Product concept fit
- Label information
- Percent share
- Trial and repeat
- Distribution
- Consumer testing

After developing the questionnaire, it was distributed to product developers and/or flavor scientists in each country to gather the requested information. Some of the questions were easily answered by the product developer or flavor scientist, but others required assistance from

additional departments within the company (e.g. marketing research). All questions were to be answered in order to collect as much information as possible for use in the data analysis.

Questionnaires were sent to the countries by email in a word processing document. Contacts from the countries then returned the questionnaires for each of the products as well a spreadsheet file with the additional data information requested. Most of the data were collected through email, but additional information was obtained by phone calls, when necessary. Multiple follow-up calls were to insure that as much data as possible were collected. Three countries were unable to fully complete the questionnaires: Argentina, India and the United States and were thus eliminated from the final data set.

Data Analysis

Data from all countries were combined into a single dataset. Scaled-item questions remained as numbers and categorical questions were changed into 0/1 dummy variables. For example, a yes-no question received a 0 for no and a 1 for yes. A question with four multiple choice answers was recorded into four dummy variables responses with one of the four responses receiving a 1 and the other three answers receiving a 0. A stepwise discriminant analysis (PROC STEPDISC in SAS[®] 9.2, Cary, NC, USA) was used to determine specific questionnaire items that best classified the data into the successful and unsuccessful categories. Wilks' Lambda multivariate test was used to determine significant differences between variables. The PROC DISCRIM function then was used to generate a classification table of correct and incorrect estimates of the data within the two groups.

The discriminant function was first performed on all the data collected on the products, including those known before launch and after launch, to determine the ability of the function to predict success. A second discriminant function was calculated using only information that

would have been known prior to, or during, the early stages of developing the product; i.e. is the product new to the overall product category?, a new variation in the category?, new variation to the country?, a familiar flavor?, whether it appears “authentic” to the culture, is it based on a traditional dish?, a dish found in most restaurants?, a trendy flavor (following an in-market trend flavor), promotes a ‘healthy’ concept, or being made with problem ingredients.

Results and Discussion

Data Gathering

The challenge in conducting studies of this type is the process of gathering the data and the impact that it can have on overall information. Data were gathered from corporate headquarters and emails were sent to the contact person in each country; they were requested to return the information within one month. Three countries responded within the requested amount of time with complete data. Reminder emails were sent to complete the information and return it. After the first reminder another four countries responded with the information. Phone calls were then used to collect the information in a discussion setting instead of through written communication. Phone call communications resulted in completion of three more countries. Finally through additional phone messages and email reminders, four more countries sent the requested information. In total, the time frame for gathering the data was approximately six months. Of the 15 original countries selected, two of the countries did not provide enough information to be included in the analysis and one country did not provide any information that was requested. From the original set of 102 products from 15 countries, data gathered from the final 12 countries resulted in a total of 63 products with adequate information.

Internal Validation of the Information Gathered

Discriminant analysis of all the data that were collected estimated 100% of the successful products as successful and 90% of the unsuccessful products as unsuccessful (Table 3.1). Thus, using information available both before and immediately after launch, the present study was able to predict success or failure almost completely. This serves as an internal validation that the information collected was useful and could predict success. Of course, using everything that was collected would not help to predict success prior to a launch because the product would need to be in the marketplace to collect some of the information.

Table 3.1. Discriminant table for percent of successful and unsuccessful flavors classified using all responses from the questionnaire

	Unsuccessful	Successful
Unsuccessful	90.0%	10.0%
Successful	0.0%	100.0%

Predicting Success with Information Known Before Launch

When limiting the collected information to the questions where information could be known prior to launch, the discriminant analysis estimated 75.8% of the successful flavored snack products as successful and 66.7% of the unsuccessful products as unsuccessful (Table 3.2).

Table 3.2. Discriminant table for percent of successful and unsuccessful flavors classified using information known prior to launch

	Unsuccessful	Successful
Unsuccessful	66.67%	33.33%
Successful	24.24%	75.76%

This prediction was found after the stepwise regression procedure reduced the 13 original variables to four significant pieces of information that could make the data more easily interpreted: 1) flavors new to snacks category in the country, 2) trendy, 3) traditional flavors and 4) flavors found in restaurants (Table 3.3).

Table 3.3. Wilks' lambda test for significant variables for attributes from stepwise regression

Variables*	Wilks' Lambda	P-value
New to snacks	0.92	0.03
Trendy	0.87	0.02
Traditional to country	0.78	0.00
Found in restaurants	0.73	0.00

*Table only shows variables that were significant at $P \leq 0.05$.

It is important to recognize that some of the significant variables have a positive impact on success and others a negative impact. Products that were successful were not new flavors to the snack food category or based on a flavor commonly found in all restaurants. This could be because new products are sometimes focused on a segmented population (i.e. specific ethnic groups or diabetics) or even that some flavors are flavor fusions of products from other countries (Watson, 2003). Although taking a product that is successful in one country and developing it to the acceptability variables of another country, unfamiliar to that flavor, can create opportunities for new food flavors (Tuorila *et al.* 1998). Success using this approach may require more market support.

New products that were successful were sometimes based on food that is traditional, has been around in the country a long time, or is a trendy concept or idea. Traditional flavors can sometimes catch the attention of an interested consumer and create impulse purchasing, then repeat purchases (Jones and Jew, 2007; Watson, 2003). Trendy flavors tag onto current market

trends (e.g. health), often generate trial purchases, and when well executed, can become staple flavors over time. When the trendy flavor is matched with quality ingredients and carefully developed, it can become the right flavor at the right time (Anon, 1999). The interest that customers have for that trendy flavor can stimulate the product in the market and create success (Rajagopal, 2008; Sheldrake, 2008). Trendy flavors, however, can also be difficult because “trends” often really are only fads, changing rapidly and making it difficult to stay at the top of the marketplace (Fortuin *et al.* 2007).

Conclusions

Predicting successful and unsuccessful products is the key to achieving better new product success rates. Collecting as much information as possible prior to launch can help to make a better prediction. This information includes collecting data even before the product is developed, such as whether the flavor is new to the overall category, a new variation in the category, a new variation to the country, a familiar flavor, ‘authentic’ to the culture, based on a traditional dish, based on dish found in most restaurants, a trendy flavor, promotes a ‘healthy’ concept, or is being made with problem ingredients. The process of collecting this information is not easy and requires patience and considerable communication between departments with the needed information. Based on this case study, however, coordinating analysis of such knowledge may be able to guide future projects to successful fruition.

For flavored snack products, using only limited general information available to the product developers, success rates of approximately 75% could be predicted. Considering approximately half of the products used in this study were unsuccessful, that improves the potential success rate by approximately 25%. Using prior known information is potentially an economical and feasible way to increase the likelihood for success.

It is possible that additional specific information on the products, such as the specific sensory characteristics of products, could improve that equation further, but such information was not available in most countries. The questions in this case study worked well for the selected flavored snack products category, but they may not be the exact same questions needed for another category of products. It is concluded, then, that the research presented in this paper identified a procedure with the kinds of questions that can be used to obtain success in a given food product category.

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Figure 3.1. Questionnaire distributed to countries to obtain more product information

Note: the specific product has been designated as \$\$ and the subcategory of snacks has been designated ## to maintain confidentiality

Country: _____

Product Name: _____

SKU: _____

Please answer the following questions.

How did this flavor product do in the marketplace?

- Successful
- Unsuccessful

Is/was the flavor product new to the category? Please check all that apply.

- New to \$\$, but exists in other categories
- New to ##, but exists in other categories
- New to snack foods, but exists in other categories
- Nothing like it

Is/was this flavor familiar to the country?

- | | | | | |
|--------------------------------|---|---|---|----------------------------|
| 1 | 2 | 3 | 4 | 5 |
| It is not a
familiar flavor | | | | It is a
familiar flavor |

Has this flavor been in the country for a long time or short time? Please check one.

- Relatively new to the country
- In culture, but not everywhere (Regional)
- Common in all restaurants in the country but not traditional of the country
- Traditional to country, has been around a long time

Is/was the flavor and name “authentic” to the product for this country?

- | | | | | |
|---------------|---|---|---|----------------|
| 1 | 2 | 3 | 4 | 5 |
| Not authentic | | | | Very authentic |

If this flavor was based on a typical food, does the flavor of the product match the “food experience”?

- | | | | | | |
|----------------------------------|---|---|---|-----------------------------------|-------------------|
| 1 | 2 | 3 | 4 | 5 | |
| Slightly matches
Authenticity | | | | Matches authenticity
Very well | Not
Applicable |

Is/was the flavor a trendy concept or idea (i.e. followed a new in-market trend for flavors)?

- No
- Yes

Is/was the product available in multiple sizes?

- No
- Yes

If yes, what sizes were available? _____

Did/does the front package design show ingredients or food context (Check all that apply)?

- Showed humans or celebrities
- Showed ingredients
- Showed food culture
- No imagery

Is/was the product readily available?

- | | | | | |
|---------------|---|---|---|------------|
| 1 | 2 | 3 | 4 | 5 |
| Not Available | | | | Available |
| Everywhere | | | | Everywhere |

Are there ingredients, other than salt, that you think consumers may have/had a problem with?

- | | | | | |
|-------------|---|---|---|---------------------|
| 1 | 2 | 3 | 4 | 5 |
| Local clean | | | | Contains multiple |
| label | | | | problem ingredients |

Is/was this product likely to be sold/eaten after the product's optimal quality?

- Yes
- No

Were/are there any shelf-life concerns?

- Yes
- No

Does the flavor promote a 'healthful' concept?

- Yes
- No

Is/was there a direct competitor?

- Yes
- No

If yes, how did the product score related to competition?

- No competitor
- Lost to competitor
- Win over competitor
- Tie competitor

Did the product meet supply demands?

- Met demands

Did not meet demands

Is/was the product in-line with other pricing, comparable to the competitor? Deal or over priced?

Deal

Comparable pricing

Premium pricing

Is/was the product launched in a season appropriate or not for the flavor?

Yes

No

***CHAPTER 4 - Creating a model for predicting
success based on descriptive sensory
characteristics: a case study on flavor snack foods***

"DO NOT GO WHERE THE PATH MAY LEAD, GO INSTEAD WHERE THERE IS NO PATH AND LEAVE A TRAIL." - RALPH
WALDO EMERSON

Abstract

The present case study of flavored snack foods describes a process for characterizing and measuring various aspects of the eating experience of a group of successful and unsuccessful product pairs. The products were either currently successful in the market or previously had been in the marketplace, but removed as failed products. Extensive descriptive testing was conducted on 34 products to create a model using the sensory attributes to predict successful and unsuccessful products. After testing, attributes from each method were added into a stepwise regression to determine the least number of attributes that were necessary to correctly predict all successful and unsuccessful products. In order to determine the best model for this set of snacks, the methods were evaluated on their own as well as in different combinations with other methods through stepwise regression and discrimination analyses. The final model correctly predicted all successful and unsuccessful products, had an R-square of 0.84 and included nine attributes, seven flavor attributes and two ratios that mainly included base notes necessary to be categorized as a snack product. In this case study, developing snacks with flavors that do not suppress these important base notes can lead to more successful product introductions.

Introduction

Market success of products is the ultimate goal for companies. To succeed in the marketplace a product must have all of the right factors necessary to survive tough competition and meet consumers' needs. Various authors have proposed what critical factors are necessary for a product to be successful including meeting marketing requirements (Krieg, 2004), timing of introduction into the market (Rajagopal, 2008), clear innovation of the creative 'up-front' testing (such as initial screenings, market assessments, market research) (Fortuin *et al.* 2007) and understanding what the consumer needs and wants (Wilson, 1994). As food companies develop new products they need additional tools to help evaluate products because failure rates currently are high.

In order to achieve a better success rate of products in the marketplace, product developers need to work with a mixture of people within the company. Considerable work has been done focusing on creating a more intensive innovation process that will assess different points along the way to make sure that the product is meeting 'guidelines' before moving into later product development phases (i.e. stage gate process, Hart *et al.* 2003; Cooper, 1992, innovation funnel, Clarke, 1996, scoring model, Cooper, 1985). Even with this approach there are many ways to go through the process and several times people within the cross-functional team can disagree on whether to let the project continue or stop (Zoumas, 2007). Fortuin *et al.* (2007) found that companies will sometimes continue to invest in an unsuccessful product project, losing money because they do not have all the information necessary to make decisions. Wilson (1994) suggests that these issues could occur because problems spots are not identified through the process; they are overlooked, or ignored.

For years researchers have proposed that using sensory testing could dramatically change the product development of the product (Kramer, 1980; Cairncross and Sjöström, 1950). Consumers are an important part of the sensory process of developing products because they can tell developers whether or not they like the product and if they will buy it (Buisson, 1995). However, repetitive consumer testing is expensive, time consuming, and often impossible. Because it is known that consumers make choices based on their preference for the product, having an understanding of what attributes contribute to being important to the consumer could translate to product success (Wansink, 2003). However, it is important to remember that consumers are unique individuals, they are different from each other and sometimes the information gathered from consumers can not be actionable, meaning it may not be possible to really create that product they want (Watson, 2003; Ohr, 2001). Since consumer testing only measures preferences for a product, there is no measure of the differences between the flavors of the product, descriptive testing is needed for this (Stone and Sidel, 2004; Kramer, 1980; Moriarty, 1966).

Another drawback of launching a product relying just on consumer testing is that it is expensive and the number of consumer tests probably will be limited for a single project (Krishnamurthy *et al.* 2007). This has led to attempting to predict consumer liking by developing prediction models by linking descriptive sensory measurements and consumer preference data. These methods have included such methods as partial least squares regression (PLS) and principal component analysis (PCA) and neural networks. Each of these methods require descriptive testing of products to predict consumer liking and help make decisions on marketing of new products (Luciano and Naes, 2009, Tenenhaus *et al.* 2005).

Sensory descriptive testing is a reliable way to optimize a product for launch into the marketplace. As early as the 1940's, formal descriptive testing was conducted on food products. When Cairncross and Sjöström (1950) published the flavor profile method there was a new standard for sensory testing; the method assigned a specific value to specific attributes found in products. The measurements are given by highly trained panelists who have been exposed to numerous odors and flavors to learn to identify specific attributes. Using these trained panelists ensures that there is no bias in the data and that the data would be reproducible (Keane, 1992; Moriarty, 1966; Caul, 1957; Cairncross and Sjöström, 1950).

In recent decades, descriptive testing typically is one of the first sensory tests performed on a product to screen prototypes that have already been developed that don't meet previously set criteria (Meilgaard *et al.* 2007). The testing should be consumer-oriented (i.e. what attributes may be important?) to keep the consumer in mind, but have a more product focused objective to determine differences in development of the product (Braghieri *et al.* 2009; Ohr, 2001).

Often times descriptive testing will take place multiple times throughout product development. Products will be formulated and descriptive tests will be conducted to define the attributes present in the prototype. Marketing may then focus on the sensory concept with focus groups. Descriptive testing will be used again to examine the products in order to identify unsatisfactory attributes that product developers will need to modify. Market research typically will take the product to large scale consumer testing, then product development will make plant produced product and descriptive testing will be needed to assure that there are no differences between the pilot plant and plant produced products. This process using test and repeat of testing between departments on the team can go back and forth several times or just a few times, but it creates a cohesive product for launch (Stone and Sidel, 2004; Sidel *et al.* 1975).

Descriptive testing has a great potential because of the ability to test large numbers of products, compare from test to test and create a map of the product category. Having the ability to conduct such multiproduct testing is far greater than only testing two or three products at a time (Stone and Sidel, 2004). Being able to guide product development with sufficient information, based on the objectives of the project, will make the project more successful.

The objectives of this study were to 1) *describe a process* for characterizing and measuring the descriptive sensory characteristics of successful and unsuccessful products and 2) determine if a model could be created using information from those sensory properties to predict success versus failure of a product case study.

Materials and Methods

This study was able to test products that a) were previously in the marketplace and found to fail and 2) current successful products. Success or failure was based on length of time in the market. An international food manufacturer agreed to provide information and samples, including remanufacturing those that had failed, for this study. The specific flavored snack food product was selected because it was widely available in many international markets in a wide variety of flavors. Conversations were held with staff in sensory analysis, product development, marketing and flavor development to gather information on specific products for selection.

Products

A single snack food base, with more than 100 flavor options, that were introduced in the past 5 years were selected. From those flavor options, 63 products flavors (33 successful and 30 unsuccessful) were selected by in-country staff using the criteria that the success or failure of the product should not have been based on market issues (e.g. extraordinary pricing, marketing

failures, unusual competition, poor market timings, etc.), but rather on product flavor issues. Those 63 products were selected from 15 countries (Argentina, Australia, Brazil, China, Egypt, India, Mexico, Poland, Russia, Spain, South Africa, Thailand, Turkey, the United Kingdom and the United States). Market and concept information was gathered on each product (Table 4.1). The questions included multiple choice questions as well as yes-no and 5-point scale questions to make it as easy as possible to collect information on these products.

Table 4.1. Categories of the questions that were asked for each product

Multiple Choice	Yes/No	5-point scale
New to category	Successful or Not	Familiarity
Pricing	Trendy concept	Problem Ingredients
Package Design	Multiple sizes	Authenticity
Competitor	'Healthy' concept	Availability
Time flavor has been in country	Shelf-life concerns	Match 'food experience'

Panelists

A panel consisting of seven highly trained descriptive panelists from the Sensory Analysis Center at Kansas State University evaluated the samples over multiple days. The professional panelists had completed 120 hours of general training and had an average of more than 2,000 hours of testing experience. Trained panelists are trained to give accurate, repeatable information about products including attributes and intensities (Chambers *et al.* 2004). Even though panelists are trained to use standardized terminology, panelists needed to be trained on the proper testing methods that would be used in this evaluation at the beginning of the panel and they were oriented to the snack products that they would be testing.

Sensory Testing Overall

The specific flavored snack products tested, from the original 63 selected, were chosen as part of the process (see Selection of Products for Testing in the Process and Results section below) and were tested using various descriptive sensory testing techniques (further described in this section). A new bag of each product was opened each day of testing to assure freshness. Samples were served in Styrofoam bowls labeled with 3 digit codes. All samples were served at room temperature.

Extensive descriptive testing was conducted on the products to understand the eating experience. Testing included product flavor profile, eating profile, extended eating profile, salivation, amplitude, high identity traits (HITS) and flavor categorization. Table 4.2 describes a brief overview of these methods.

Table 4.2 Descriptive testing methods overview

Method	Data Collected	Scale	Number of terms evaluated
Flavor Categorization	Major categories of flavor	Percentage of categories (must equal 100%)	1 to 3
HITS	Simple terms of flavor	1 = slight, 2 = moderate, and 3 = strong	1 to 5
Flavor Profile	Complex terms of aroma, flavor, aftertaste, amplitude	0 = none to 15 = high with 0.5 increments	Undetermined
Salivation	Measurement of salivation	Gram weight	1
Eating Profile	Time scale of flavor and aftertaste terms identifying when intensity changes are occurring	0 = none to 15 = high with 0.5 increments	Usually no more than 10
Extended Eating Profile	Multiple bites of the product over a longer period of time evaluating intensity of main flavors	0 = none to 15 = high with 0.5 increments	3 to 8

Product flavor profiling is a consensus evaluation from the panelists. Attributes were evaluated for aroma, flavor and texture of each product adapted from previous research (Keane, 1992; Caul, 1957). Each attribute was scored based on a scale from 0=none to 15=high with 0.5 point increments. References were used for each attribute to calibrate the measurements to the same scale. Other research has used adaptations of flavor profiling techniques to evaluate attributes for different categories such as almonds (Civille *et al.* 2010), black walnut syrup (Matta *et al.* 2005), green tea (Lee and Chambers, 2010) and lip products (Dooley *et al.* 2009).

The eating profile is an extension of the flavor profile with a time-intensity adaptation. For the eating profile, the panelists evaluated each flavor and aftertaste attribute found in the flavor profiles on a time scale. Panelists took 1 bite (approximately 2"x1") and consumed to the point of swallowing. While chewing the product they evaluate each point at which a change in intensity is noted. At a minimum, they evaluate the intensity at the time the attribute first appears in the flavor, at its highest intensity and swallowing, and at various points of time in the aftertaste, but other points may be evaluated if an intensity change occurs. With appropriate rinsing, the product can be re-tasted in order to have accurate moments and intensities.

The extended eating profiling is a multiple flavor profile that is similar to the eating profile except that it takes place over a longer period of time using multiple bites without rinsing. Panelists take 1 bite and consume to the point of swallowing. They then evaluate for key defining attributes of the product category at the highest intensity, evaluated on the same scale used in the previously described techniques. Sixty seconds elapsed between each bite. It is important to expose the sample to all mouth surfaces while chewing a single bite in order to make adequate flavor assessments. Evaluation of each attribute occurs after 1 bite, 6 bites, 12 bites, 18 bites and 24 bites. There was no re-tasting for a bite and no eating or drinking in

between bites. One sample was evaluated in one continuous session and only one sample was evaluated per day.

A chew and spit salivation method where the panelists received a pre-weighed sample in a pre-weighed cup (Chapter 2) was used to measure salivation potential for each flavor. Panelists were to chew the sample until the point of swallow and then expectorate into the pre-weighed cup. Panelists were given 10mL of water to rinse their mouths with and then expectorate into the same cup as before. Final weights were taken of the cups to determine amount of salivation collected during the chewing process.

Testing for amplitude (Caul 1957), or the balanced/blended character of flavors, involved evaluating a combination of attributes: impact, balance, blended, complexity, longevity and overall amplitude. The amplitude characteristics were evaluated on the same 15-point scale as the flavor profile. Those attributes together help to describe/understand the personality of the product being evaluated. Thompson *et al.* (2009) identified amplitude as a key aspect for ice cream and gelato where the Italian gelati had higher scores than the U.S. gelati on most of the amplitude attributes.

For evaluation of HITS – High Identity Traits (Talavera-Bianchi *et al.* 2010), panelists were instructed to use simple descriptive terms that were not as complex as some of the terms used in the flavor profiling method used earlier. The number of terms depended on the flavors of the snack food products being tested. A maximum of five HITS were allowed for each sample, and a minimum of 1 HIT was required. The level of intensity was assigned based on slight, moderate and strong. Perrin and Pagès (2009) used terms such as ‘very,’ ‘slightly,’ ‘not,’ and ‘without’ to provide intensities for red wines evaluated by wine professionals. Talavera-Bianchi

et al. (2010) used the HITS method and found that cheeses were clustered together similar to other studies that were conducted on cheese using this much faster method of grouping products.

A flavor categorization technique was used to group flavors into similar categories. This technique consisted of a generalized group of 16 attributes that were grouped into seven major categories based on similarity. The major categories included animal product flavors, seafood flavors, plant flavors, spicy, sweet, sour and creamy flavors. Each of the major categories had between two and four sub-categories. The panel could classify the products into no more than three categories that could describe the key characteristics of each flavor/profile. After categorization, the panel gave a percentage of 'appropriateness' for each of the chosen categories. The total percentage had to equal 100.

Converting Data

Eating profiles and extended eating profiles were evaluated by using the idea, but not the methods, of temporal dominance of sensation (TDS) (Labbe *et al.* 2009, Pineau *et al.* 2009, Meillon *et al.* 2009, Lenfant *et al.* 2009) to identify attributes that are considered dominate at certain points in time during evaluation. Time points were selected from the data that represented moments that products were evaluated. For the eating profile, seconds 2, 4, 8, 15, 30 and 60 were chosen for data analysis. Second 2 was chosen because flavors would have already been activated in the mouth. Seconds 4 and 8 (a multiple of 4) were chosen because they were points where peaks in the flavor could occur (determined by evaluating at the data). Second 15 was when the panelists swallowed the product. Seconds 30 and 60 were aftertaste evaluations that were chosen because these time points for aftertaste are already being determined in the flavor profile (also multiples of each other).

The extended eating profile collected data based on bites. For data analysis on bites, data were evaluated at bite 1, 6, 12, 18, and 24 minutes. Bite 1 was chosen as a baseline measure for the attributes being evaluated. Bite 6, 12 and 18 are multiples of 6 which collect data at multiple points, but does not over collect information providing too much to be analyzed. Bite 24 was the last bite of product that was taken before being able to drink and rinse the mouth.

Process and Results

Selection of Products for Testing

Snack products were chosen from 13 countries for testing based on previously collected market information on each product. To reduce the impact of specific market information effects (such as market demands, authenticity, etc) a cluster analysis was performed for all 63 products using the market information provided by the in-country research and development and marketing staff for each product. The products were analyzed using PROC CLUSTER in SAS[®] (9.2, Cary, NC, USA) and Wards method and were clustered into three groups representing market situations (Table 4.3). Based on that analysis, 34 products were chosen from the three clusters. Products were selected in pairs to ensure that a successful and an unsuccessful product from a country were chosen from the same cluster. Successful products were classified as products that had been in the market longer than one year and unsuccessful products were those that had been removed from the market in less than one year. This step also reduced the impact of market information on the predictive equation by eliminating flavors that did not have another flavor “match” for particular market conditions. Although we eliminated a number of products initially where success or failure were perceived as market driven, this step eliminated data from two countries where market considerations (successful products were in one cluster and

unsuccessful products from that country were in another cluster) appeared stronger than sensory issues.

Table 4.3 Attributes that distinguish the clusters

Cluster	Attributes
1	Familiar flavor Authentic flavor Flavors match food experience Typically wins over competition Does not have any problem ingredients in product
2	Not new flavors to the category Familiar flavors Flavors match food experience Met demands of the market Does not have any problem ingredients in the product Are readily available
3	Flavors not found in all regions Flavor not found in all restaurants Flavor matches food experience (if there was one) Met demands of the market Does not have any problem ingredients in the product

Step 1

This step began the determination of what sensory attributes could be used to predict product success. Descriptive data, starting with the simplest data, was used to begin the predictive process (Step 1, Table 4.8). In this study, the simplest data was the data with the fewest data points for each product. Thus, data from flavor categorization, which had a maximum of seven major categories, and HITS, which had a maximum of 37 attributes, were examined first.

The flavor categorization data was analyzed using PROC CLUSTER in SAS® and the Wards method. There were five clusters formed from the major categories. Successful and unsuccessful products did not separate into different clusters. Not surprisingly, this simple sensory data alone was not able to predict success.

The HITS information was analyzed next using the same analysis technique as for flavor categorization, but based on whether or not each of the 37 HITS attributes was present in the product or not. The data determined four clusters, but none of the clusters gave a clear separation of the products based on whether they were successful or unsuccessful. Thus, this expanded simplified sensory data also was not able to differentiate success when used alone.

Step 2

More extensive descriptive data from the flavor profile (including aftertaste) was evaluated next. Because this data is quite complex, including more than 125 attributes with many attributes that are present in only a few samples, multiple approaches to analyzing the data were attempted. Flavor in mouth (not including aftertaste) was analyzed first because it is the major contributor to the product category – flavored snack foods.

The flavor data was duplicated to create three different data approaches: actual scores (given by the panelists); whether an attribute was present or not; and intensity range (not present, low, medium, high). Scores included all raw intensity scores assigned from the panelists' using the 0-15 scale. Present/not present was used to classify when the attribute was present, it was assigned 1, and if the attribute was not present, a 0 was assigned. For range, the data was classified into 3 groups: 1 being intensity scores from 0.5-3; 2 being intensity scores from 3.5-6 and 3 being intensity scores 6.5 and higher.

Each approach was analyzed using PROC STEPWISE in SAS[®] to create a regression model. Stepwise regression takes the attributes, starting with the most related and adds and/or deletes (positive or negative) attributes adjusting the model until it is significant.

The initial step was to take 88 in mouth flavor attributes and conduct a stepwise regression on the products using the three different data approaches (Step 2, Table 4.8). Table

4.4 shows the R-square value for each of the models created. Although the present/not present data approach for all attributes gave an R-square of 1.00 which is a perfect fit, the attributes that were used to predict successful and unsuccessful did not make reasonable sense, appear to be a simple dichotomous segregation, and is unbelievable in terms of accurate predictions.

Table 4.4 R-square values for the three data approaches using all flavor attributes

	Present/Not	Scores	Ranges
All flavor attributes (88)			
R-square	1.00	0.74	0.88
Stepwise Reduced Number of Attributes	12	7	11
Residual Plot – products crossing 0.5	No	Yes	Yes

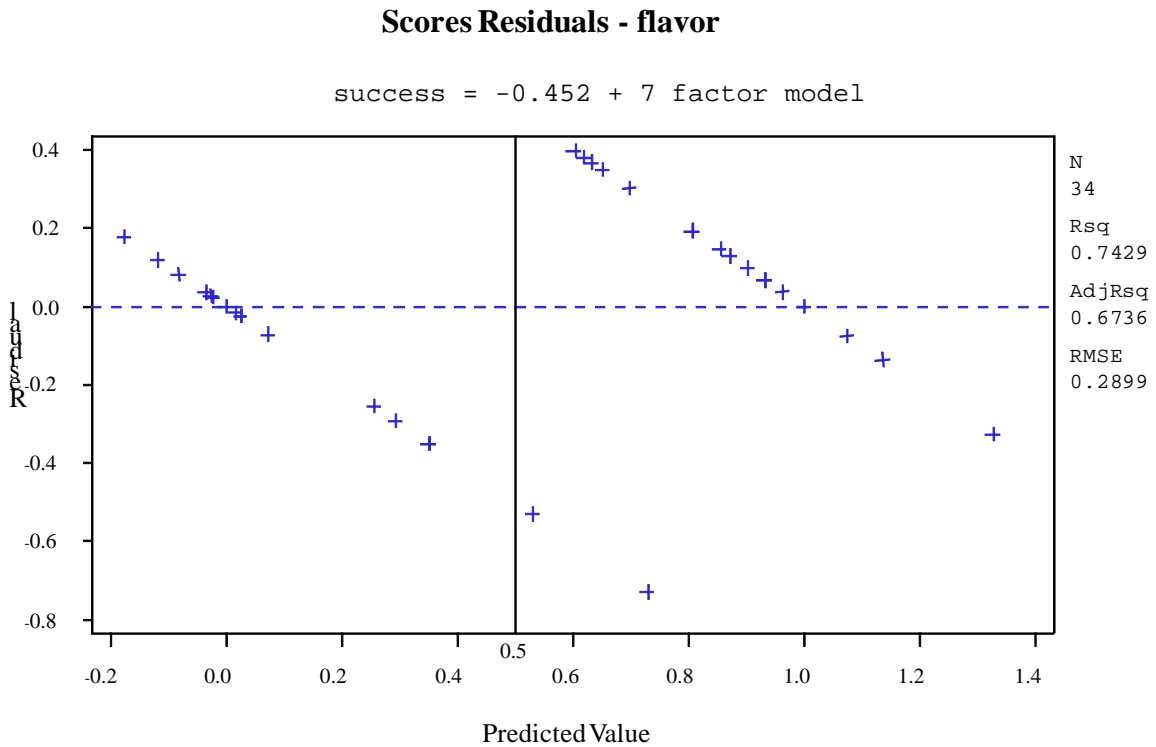
*Number in parenthesis () is the number of total attributes found when minimized down by number of products attributes are found in.

The range data approach for all flavor attributes resulted in a high R-square as well, 0.89, perhaps based on the same circumstances as the present/not present approach. Again, the attributes selected were minor attributes appearing in only one or a few products and suggest this data is a simple segmentation based on unique attributes and is unreliable as a future predictor of success. The scores data approach had an R-square of 0.74 with seven attributes that are possibly good predictors of success. However, even though the attributes seem to make sense that they could predict success more analysis of the data was needed to determine if they actually were making accurate predictions.

Since stepwise regression reduced the number of attributes being used to create the model, the reduced attributes were then plotted onto a residuals regression plot (Figure 4.1) using PROC REG in SAS®. In a perfect prediction, the residuals plot from the regression should not have any misclassified products crossing over 0.5 on the plot. Using the seven attributes selected from the scores data approach, there are products that cross over the residual plot at the 0.5

predicted value. This crossover means there are products that are being incorrectly predicted or classified as successful or unsuccessful.

Figure 4.1. Residual plot with product points crossing over the 0.5 predicted value



Step 3

Because of the range of flavors present in this study, there were many attributes present in only one or a few products. Those “unique” attributes often served only to segment one unsuccessful product, which serves as a statistical predictor, but not a practical one. Thus, the next step was to examine only attributes that were present in multiple samples in order to make a more accurate prediction of successful and unsuccessful products (Step 3, Table 4.8). Attributes were minimized by using only the attributes that were present in a certain number of products (Table 4.5). For example, when examining the raw data only 31 of the 88 flavor attributes were

present in three or more of the products tested. Twelve of the attributes were present in eight or more of the products (25%) tested.

Table 4.5 R-square values for the three data approaches using flavor attributes that were present in various amounts of products

	Present/Not	Scores	Ranges
Attributes in 8 or more products (12)*			
R-square	0.95	0.40	0.36
Stepwise Reduced Number of Attributes	1	3	3
Residual Plot – products crossing 0.5	No	Yes	Yes
Attributes in 7 or more products (13)*			
R-square	0.95	0.40	0.36
Stepwise Reduced Number of Attributes	1	3	3
Residual Plot – products crossing 0.5	No	Yes	Yes
Attributes in 6 or more products (17)*			
R-square	0.19	0.36	0.45
Stepwise Reduced Number of Attributes	2	2	4
Residual Plot – products crossing 0.5	Yes	Yes	Yes
Attributes in 5 or more products (20)*			
R-square	0.19	0.36	0.45
Stepwise Reduced Number of Attributes	2	2	4
Residual Plot – products crossing 0.5	Yes	Yes	Yes
Attributes in 4 or more products (23)*			
R-square	0.19	0.36	0.45
Stepwise Reduced Number of Attributes	2	2	4
Residual Plot – products crossing 0.5	Yes	Yes	Yes
Attributes in 3 or more products (31)*			
R-square	0.56	0.80	0.78
Stepwise Reduced Number of Attributes	6	8	8
Residual Plot – products crossing 0.5	Yes	No	Yes

*Number in parenthesis () is the number of total attributes found when minimized down by number of products attributes are found in.

After minimizing the attributes down, based on the number of products each attribute was present in, the data began to have more reliable data. Again, the attributes were analyzed using PROC STEPWISE in SAS® and residual plots.

Attributes present in eight or more products (<25%) reduced the number of predictor attributes to three or fewer in all of the approaches (Table 4.5). These three attributes were identified as ‘base’ notes, meaning that they contribute to the base of the product, not the flavoring that is added to the product. These ‘base’ notes were consistently found as the attributes were reduced, based on the products they were present in. For both the score and range approaches, limiting the number of attributes, based on the number of products, helped to increase the R-square. Even though the R-square is highly significant, these models still were unable to identify successful products.

Although “base” notes are important, flavored snack products rely on added flavors and the impact of those is not understood when only three base flavors are evaluated. In addition, an R-square of 0.40 is low (scores approach) and suggests that the model is not highly predictive. The present/not present approach was eliminated because it produced nonsense data (i.e. one attribute explanations). Also, because the score and range approaches produced similar results, the range approach was discontinued because it requires an additional step of converting the data into ranges. Limiting down to one approach can be helpful to simplify the data process.

Step 4

Ratios of product properties have been shown to provide useful information on product acceptance (e.g. the Brix/acid ration for orange juice is related to quality). Thus, the next step was to add ratios of key flavor characteristics to analysis that included the individual flavor attributes (Step 4, Table 4.8). Only attributes present in all products were used as denominator attributes and attributes present in eight or more products were used as the numerator attributes for determining ratios. The 40 ratios and 88 flavor attributes, regardless of the number of product in which they were present, were reduced through PROC STEPWISE in SAS® resulting

in 32 attributes or attribute ratios and an R-square of 1.00. In this case, the 32 attributes/ratios probably represent a mathematically perfect solution, but not a realistic or practical one that would describe the category. The number of attributes is too large to be helpful to a product developer. This large number of regression factors may be the result of increasing the number of total possible regression solutions by including 40 additional ratios.

Step 5

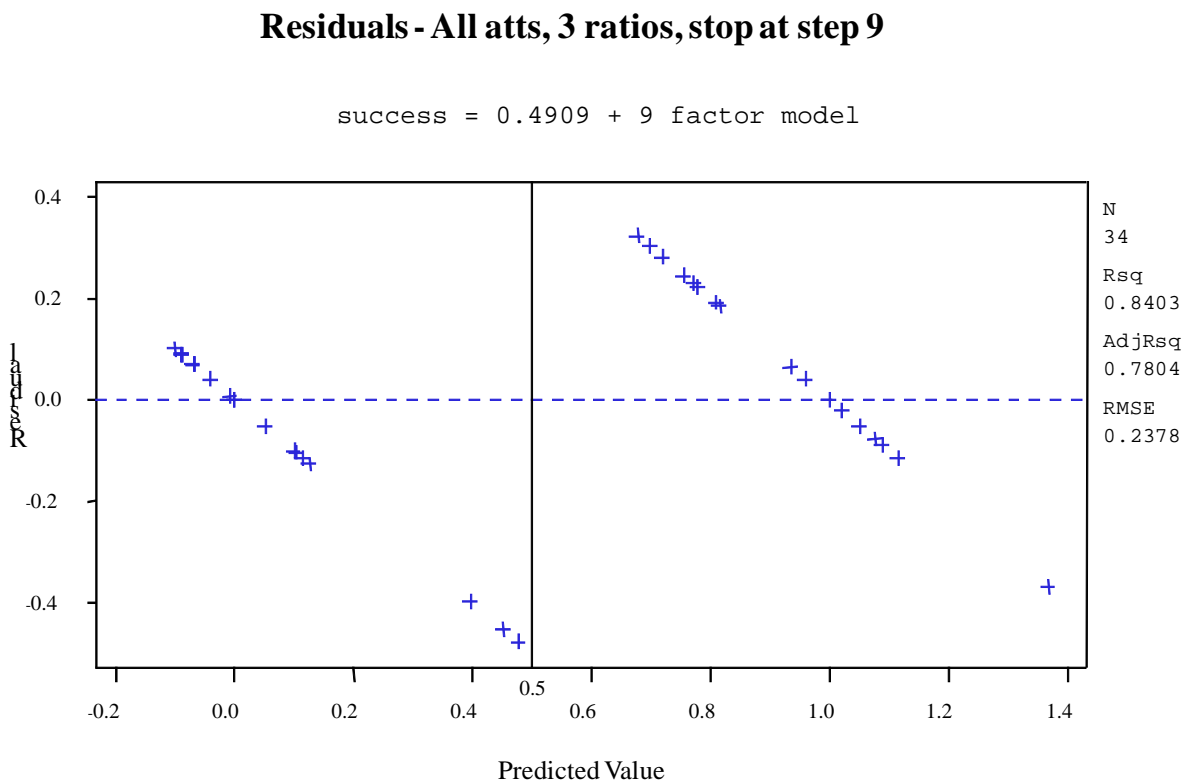
This step was included to determine if key ratios exist that could be added to the overall analysis to reduce the impact of adding 40 additional factors. In this step, the ratios from the previous step and attributes that were present in eight or more products (>25% of tested snacks) were selected as providing a good representation of the attributes possible to predict success. Those attributes were reduced through PROC STEPWISE in SAS[®] (Table 4.8). This resulted in an R-square of 0.54, which is an increase from the R-square 0.40 from the flavor attributes present in eight or more products alone (step 4). The reduced model contained five attributes and ratios: two attributes and three ratios. These three ratios included the base notes previously determined to be important in step 4, concluding that the ratios of these attributes are possibly more important than the individual flavors.

Step 6

The selection in step 6 of three key ratios that included important base attributes suggested that those ratios could be added to the 88 flavor attributes for further study (Step 6, Table 4.8). Thus, in this step, the three ratios and all the flavor attributes were combined for analysis. These attributes and ratios were analyzed with PROC STEPWISE in SAS[®] and the reduced stepwise regression resulted in nine attributes/ratios: seven attributes and two ratios and a much improved R-square of 0.84.

These nine attributes/ratios provide a 100% correct classification of successful and unsuccessful products as shown by the regression residuals plot (Figure 4.2) and based on PROC DISCRIM in SAS®. Because one of the attributes in a ratio was not present in many samples, a discriminant analysis was conducted without that ratio, but the prediction of successful and unsuccessful products dropped to 88.2%. Because this occurred, it was determined that the model with all nine attributes/ratios was a reasonable predictor of success. From this point on in the process this reduced model to nine attributes will be called ‘Model 9’.

Figure 4.2. Residual plot with the product point not crossing over the 0.5 predicted value



Step 7

Throughout the analyses it became obvious that the base flavor notes were important in the snack category. In order to assure that the base notes were important, base notes were

removed to see if the added flavor attributes could explain success on their own (Step 7, Table 4.8). When all methods were added into the stepwise for no base attributes, the number of attributes found could not be reduced to fewer than 13 with an R-square of 0.93, a higher number of attributes than Model 9. This model suggests that for this category, the presence of base flavor notes is important to successful products and must not be covered up by a flavor and the added flavor must not “fight” with the base flavor notes.

Step 8

Although at this point a reasonable prediction of success occurred, additional more complex descriptive information had been gathered that had not been included to this point. Is it possible to determine success using that information alone or in addition to the other flavor characteristics? A key is that the prediction should provide a success criteria at least as good as Model 9 while reducing the number of attributes necessary for explanation.

Amplitude, aroma and aftertaste attributes, and salivation were analyzed separately and added individually into PROC STEPWISE in SAS[®] equation with Model 9 (Table 4.6). Even though some of the R-squares are high, none of this information reduced the number of attributes to 9 or fewer to improve on Model 9’s prediction of success. These results suggest that these additional or more complex measures do not add to the prediction of success. That does not support Moriarty’s suggestion (1966) that well blended, full bodied flavors contribute to a successful food products. Nor does this data suggest that ‘makes my mouth water’ or salivation added anything to the ability to predict success in this case study.

Table 4.6 R-square and number of attributes reduced to by stepwise for remaining parts of the flavor profile method and salivation

	Amplitude	Aroma	Aftertaste	Amplitude, Aroma, Aftertaste	Salivation
Method on own (no other attributes)					
R-square	0.16	0	0.88	0.91	0.23
Stepwise Reduced Number of Attributes	6	0	10	10	1
Method added into Model 9					
R-square	0.86	0.92	0.90	0.85	0.83
Stepwise Reduced Number of Attributes	10	16	12	11	9

Step 9

Eating and extended eating profiles were also considered in the model reduction (Table 4.8). The eating profile data was selected at seconds 2, 4, 8, 15, 30 and 60. Using only the eating profile data the model selects 8 attributes, providing a higher R-Square (0.91) than Model 9 with eight completely different attributes (Table 4.7).

Table 4.7 R-square and number of attributes reduced to by stepwise for more complex sensory methods

	Eating Profile ^a	Extended Eating Profile ^b
Method on own (no other attributes)		
R-square	0.91	0.70
Stepwise Reduced Number of Attributes	8	9
Method added into Model 9		
R-square	0.91	0.88
Stepwise Reduced Number of Attributes	8	10

When eating profiles data are added to Model 9 predictors, there is not a change in the R-square or the number of attributes being used for prediction because the 8 being used to predict

success are the same attributes used without adding Model 9. The eating profile method requires considerably more time, money, and product to collect the data. Thus, this method could be used as a separate method to assure that the previous model is accurate, but probably should not replace the more familiar and similar descriptive methods that could be used to predict success.

For extended eating, data was collected based on bites of product at 1, 6, 12, 18, 24 minutes. Extended eating profile alone resulted in reduced nine attributes. However since nine was already determined previously with Model 9, that are not as complex as the extended eating profile, this model cannot be considered an improvement to Model 9. When evaluating the extended eating profile only one sample can be performed in a session because of build-up of flavors due to not being able to cleanse properly. This time commitment requires more time to perform this method compared to other descriptive methods and again, may provide information, but does not replace the current descriptive methods.

Step 10

Until this step, attributes have been added at separate times in the stepwise regression. It is important to consider what having all attributes added at one time can produce (Step 10, Table 4.8). All possible subsets regression is a commonly used technique for examining all the potential factors that could be used to explain the data. However, using this technique with the large number of data points in this research requires a supercomputer that is unlikely to be available to most sensory scientists. Thus, in order to find an all possible subsets regression, PROC VARCLUS in SAS® was used to cluster all of the attributes and ratios into clusters of similar variables. There were 44 clusters developed which was limited down to 22 of the attributes by selecting the highest R-square value from each of the clusters. If there was a tie within a cluster, both attributes were taken if they were both descriptors of the attributes in the

cluster, if they were related, then only one attribute was chosen. Also, the limited attributes had to be present in at least four products in order to reduce the number of attributes to a manageable amount to calculate the residual plot.

These 22 attributes were used in PROC PHREG in SAS® to develop subset models for all of the attribute ranges (1-22). From each of the predicted models, with fewer than nine attributes (since success can already be predicted with Model 9) two of the models were chosen. These models had the highest chi-square scores compared to the other models for the same number of attributes. The attributes from the models were plotted on a residual plot resulting in 13 plots created. Of these 13 plots, none of them generated a residual plot with points that did not cross the 0.5 predicted value. Thus, none of these predicted models can predict 100% success, which already was achieved with Model 9.

Table 4.8 Process of determining what attributes are needed to help predict success

Step	Descriptive Method	Data Analysis	Question to ask *Guidelines only, the specific questions may differ.
1a	Flavor Categorization	Cluster	Are the clusters separated by successful and unsuccessful products?
Decision	Do the clusters clearly separate successful and unsuccessful products apart? If yes, major flavor categories have been identified. Regardless, continuing with the steps is recommended to obtain more flavor details.		
1b	HITS	Cluster	Are the clusters separated by successful and unsuccessful products?
Decision	Do the clusters clearly separate successful and unsuccessful products apart? If yes, high identity traits have been identified. Regardless, continuing with the steps is recommended to obtain more flavor details.		
2-1	Flavor Profile – Flavor Raw Scores Approach	Stepwise	What is the R-square? Do the attributes make sense to describe the prediction of success for the category? Does it only describe minor attributes present in only a few products which may not describe the whole category? Are any of the products misclassified? Do any of the products cross over 0.5
		Regression	
2-2	Flavor Profile – Flavor Present/Not Present Approach	Stepwise	
		Regression	
2-3	Flavor Profile – Flavor Range Approach	Stepwise	
		Regression	

			on residual plot?
Decision	Can 100% prediction occur? What is the least number of attributes needed to predict 100%? Continue to determine if other attributes or minimizing the number of attributes will predict success/failure of more products.		
3-1	Flavor Profile – Minimizing Flavor Raw Scores Approach	Stepwise	What is the R-square? Do the attributes make sense to describe the prediction of success for the category? Does it only describe minor attributes that are only present in a few products which may not describe the whole category?
3-2	Flavor Profile – Minimizing Flavor Present/Not Present Approach	Stepwise	
3-3	Flavor Profile – Minimizing Flavor Range Approach	Stepwise	
Decision	Can 100% prediction occur? What is the least number of attributes needed to predict 100%? Which approach resulted in the highest R-square with the least number of reasonable attributes? Continue to determine if ratios of different attributes will predict success/failure of more products.		
4	Ratios with all Flavor	Stepwise	What is the R-square? Do the attributes make sense to describe the prediction of success for the category? Are there key ratios?
5	Ratios with Minimized Flavor	Stepwise	
6a	Key Ratios with all Flavor	Stepwise	
6b	Key Ratios with all Flavor	Discriminate	Are any of the products misclassified? What is the percent of misclassified products?
Decision	Can 100% prediction occur? What is the least number of attributes needed to predict 100%? Do any of these reduce the number of attributes needed to predict 100%? Continue to determine if only base notes or removing base notes will predict success/failure of more products.		
7	Remove Base Notes	Stepwise	What is the R-square? Do the attributes make sense to describe the prediction of success for the category?
Decision	Can 100% prediction occur? What is the least number of attributes needed to predict 100%? Do any of these reduce the number of attributes needed to predict 100%? Continue to determine if attributes from other parts of the flavor profile or salivation will predict success/failure of more products, using less attributes than previously determined.		
8a	Flavor Profile – Aroma	Stepwise	What is the R-square? Do the attributes make sense to describe the prediction of success for the category?
8b	Aroma with Minimized all Flavor and Key Ratios	Stepwise	
8c	Flavor Profile – Aftertaste	Stepwise	
8d	Aftertaste with Minimized all Flavor and Key Ratios	Stepwise	
8e	Flavor Profile – Amplitude	Stepwise	
8f	Amplitude with Minimized all Flavor and Key Ratios	Stepwise	

8e	Minimized all Flavor and Key Ratios with Aroma, Aftertaste and Amplitude	Stepwise	
8f	Salivation	Stepwise	
8g	Minimized all Flavor and Key Ratios with Salivation	Stepwise	
Decision	Can 100% prediction occur? What is the least number of attributes needed to predict 100%? Do any of these reduce the number of attributes needed to predict 100%? Continue to determine if using more complex methods is worthwhile to test by predicting more success/failure products, using less attributes.		
9a	Eating Profile	Stepwise	What is the R-square? Do the attributes make sense to describe the prediction of success for the category?
9b	Minimized all Flavor and Key Ratios with Eating Profile	Stepwise	
9c	Extended Eating Profile	Stepwise	
9d	Minimized all Flavor and Key Ratios with Extended Eating	Stepwise	
Decision	Can 100% prediction occur? What is the least number of attributes needed to predict 100%? Do any of these reduce the number of attributes needed to predict 100%? Continue to determine if adding all attributes together at once will predict success/failure products, using less attributes.		
10a	All attributes, ratios – Everything	Varclus	How many clusters are developed? What are the key attributes of each cluster?
10b	Selected Attributes from Varclus	PHREG	How many predicted models are created? Which models have the highest chi-square?
10c	Models from PHREG	Regression	Are any of the products misclassified? Are any of the products crossing over 0.5 on the residuals plot?
Decision /Result	Can 100% prediction occur? What is the least number of attributes needed to predict 100%? Do any of these reduce the number of attributes needed to predict 100%? Use the method or combination of methods that best predicts the products by using the least number of attributes and/or the simplest methods.		

Overall Process

This process used nine different sensory methods to predict 34 successful and unsuccessful products (Table 4.8). The end result for this study was a model using nine attributes/ratios: two ratios and seven attributes that predicted 100% success and failure. Many of the attributes were base notes that were necessary for the product to be successful. When

looking at this data set of flavored snacks products, the base notes must be present in the product and should not be removed from or covered up by flavors that are not appropriate for the product.

Conclusions

For developing a model that can be used to predict success for any category it was important to look at a range of descriptive sensory panel methods to collect a range of data. Using all of these methods ensures that nothing is overlooked or missed in the products being tested. Although the actual predictive model will differ and the specific types of sensory tests needed will vary depending on the product category, this study established a framework process for examining success based on sensory properties.

For this flavored snack category, nine attributes, collected from basic flavor profiling, was necessary for 100% prediction of success. Adding in the more complex sensory methods, the amount of time and cost do not supersede the easier method. In addition, more testing is necessary to determine details of the eating profile that are necessary to obtain accurate results for predicting success. In this category, base notes were important and not losing those base notes when flavors were added tended to provide success. That may differ for other categories, but the process of examining sensory properties would remain the same.

All through the process of adding sensory information to create a successful prediction it is important to look at the attributes and make sure they make sense in the prediction. As with this data set, some of the models that were highly predictable didn't give information that could be accurately used with a data set different than the one being tested.

It is important to remember that the current data set included a wide range of flavors in the snack category; differences among products were not subtle. Other categories or more

focused categories may require more complex tools for predicting product success. Thus, when beginning a process of predicting product success based on past product performance, we recommend that the full range of data be collected to ensure that sufficient information is available for modeling.

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Appendix A - SAS® code used for analysis in Chapter 2. A comparison of methods for measuring salivation to food products.

Phase I – General Linear Model – Spit Method

```
Title 'Chapter 2 – Phase I – Spit';  
data spit;  
input product $ code rep panelist salivation;  
cards;  
[DATA]  
;  
proc means data = spit;  
var salivation;  
by product;  
run;  
proc glm data = spit;  
class product rep panelist;  
model difference = product rep panelist product*rep panelist*product panelist*rep;  
means product rep panelist product*rep panelist*product panelist*rep/LSD lines;  
lsmeans product rep panelist product*rep panelist*product Panelist*rep/psdiff stderr;  
run;
```

Phase I – General Linear Model – Cotton Method

```
Title 'Chapter 2 – Phase I – Cotton';  
data cotton;  
input product $ code rep panelist salivation;  
cards;
```

```

[DATA]
;
proc means data = cotton;
var salivation;
by product;
run;
proc glm data = cotton;
class product rep panelist;
model difference = product rep panelist product*rep panelist*product panelist*rep;
means product rep panelist product*rep panelist*product panelist*rep/LSD lines;
lsmeans product rep panelist product*rep panelist*product Panelist*rep/psdiff stderr;
run;

```

Phase I – General Linear Model – Scale Method

Title 'Chapter 2 – Phase I – **Scale**';

```

data scale;
input product $ code rep panelist salivation;
cards;
[DATA]
;
proc means data = scale;
var salivation;
by product;
run;
proc glm data = scale;
class product rep panelist;
model difference = product rep panelist product*rep panelist*product panelist*rep;
means product rep panelist product*rep panelist*product panelist*rep/LSD lines;
lsmeans product rep panelist product*rep panelist*product Panelist*rep/psdiff stderr;
run;

```

Phase II – General Linear Model – Flavor Testing

Title 'Chapter 2 – Phase II – Spit method for flavor';

data flavor;

input product \$ code rep panelist salivation;

cards;

[DATA]

;

proc means data = flavor;

var salivation;

by product;

run;

proc glm data = flavor;

class product rep panelist;

model difference = product rep panelist product*rep panelist*product panelist*rep;

means product rep panelist product*rep panelist*product panelist*rep/LSD lines;

lsmeans product rep panelist product*rep panelist*product Panelist*rep/psdiff stderr;

run;

Appendix B - SAS® code used for analysis in Chapter 3. Predicting success for new flavors with information known before launch: A flavored snack food case study

Discriminant Analysis – All Questions from Questionnaire

Title 'Chapter 3 –Discriminant analysis – all questions';

data questionnaire;

input product \$ country \$ Success b c d e f g h I j k l m n o p q r s t u v w x y z aa ab ac ad ae af ;

cards;

[DATA]

;

proc discrim data = questionnaire out=outQ anova manova;

class success;

var b c d e f g h I j k l m n o p q r s t u v w x y z aa ab ac ad ae af ag ah;

run;

Discriminant Analysis – Questions that would be known prior to launch into marketplace

Title 'Chapter 3 –Discriminant analysis – prior to launch questions';

data PRIORtoLAUNCH;

input product \$ country \$ Success b c d e f g h I j k l m n ;

cards;

[DATA]

;

proc discrim data = PRIORtoLAUNCH out=outQ anova manova;

class success;

var b c d e f g h I j k l m n ;

run;

Stepwise Discriminant Analysis – Questions that would be known prior to launch into marketplace

Title 'Chapter 3 – Stepwise discriminant analysis – prior to launch questions;

data PRIORtoLAUNCH;

input product \$ country \$ Success b c d e f g h I j k l m n ;

cards;

[DATA]

;

proc stepdisc data = PRIORtoLAUNCH bsscp tsscp;

class success;

var b c d e f g h I j k l m n ;

run;

Appendix C - SAS® code used for analysis in Chapter 4. Creating a model for predicting market success based on descriptive sensory methods: A case study on flavor with snack foods

Cluster Analysis – Ward Method – Limiting products for testing

Title 'Chapter 4 – Cluster analysis;

data cluster;

input product \$ country \$ Success b c d e f g h I j k l m n;

cards;

[DATA]

;

proc cluster data = cluster s method=ward ccc pseudo outtree=tree;

var b c d e f g h I j k l m n;

id product;

run;

proc plot data=tree;

plot _ccc_*_NCL_=_NCL_/Haxis=0 to 16 by 2;

run;

proc tree data=tree out=treeout ncluster=16;

run;

Cluster Analysis – Ward Method – Flavor Categorization

Title 'Chapter 4 – Cluster analysis – Flavor Categorization;

data categorization;

input product \$ country \$ Success b c d e f g h I j k l m n o p q r s t u v w;

cards;

[DATA]

```

;
proc cluster data = categorization s method=ward ccc pseudo outtree=tree;
var b c d e f g h I j k l m n o p q r s t u v w;
id product;
run;
proc plot data=tree;
plot _ccc_*_NCL=_NCL_/Haxis=0 to 16 by 2;
run;
proc tree data=tree out=treeout ncluster=16;
run;

```

Cluster Analysis – Ward Method – for HITS

```

Title 'Chapter 4 – Cluster analysis – HITS;
data HITS;
input product $ country $ Success b c d e f g h I j k l m;
cards;
[DATA]
;
proc cluster data = HITS s method=ward ccc pseudo outtree=tree;
var b c d e f g h I j k l m;
id product;
run;
proc plot data=tree;
plot _ccc_*_NCL=_NCL_/Haxis=0 to 16 by 2;
run;
proc tree data=tree out=treeout ncluster=16;
run;

```

Stepwise Discriminant Analysis – Applied Multiple Time Throughout Process

Title 'Chapter 4 – Stepwise discriminant analysis;

data stepwise;

input product \$ country \$ Success b c d e f g h I j k l m n o p q r s t u v w x zz;

cards;

[DATA]

;

proc stepwise data = stepwise;

model success = b c d e f g h I j k l m n zz ;

run;

Stepwise Discriminant Analysis – With Ratios - Applied Multiple Time Throughout Process

Title 'Chapter 4 – Stepwise discriminant analysis;

data stepwise;

input product \$ country \$ Success b c d e f g h I j k l m n o p q r s t u v w x zz

ratioA = r/p;

ratioB = z/p;

[ratios cont.];

cards;

[DATA]

;

proc stepwise data = stepwise;

model success = b c d e f g h I j k l m n zz ;

run;

Regression Analysis – Applied Multiple Time Throughout Process

Title 'Chapter 4 – Regression analysis;

data regression;

input product \$ country \$ Success b c d e f g h I j k l m n o p q r s t u v w x ZZ;

cards;

[DATA]

;

proc reg data = regression;

model success = b c d e f g h I j k l m n ZZ ;

plot residul.*predicted;

output out=flavor_reg1 p=predict r=resid rstudent=rstudent;

run;

Discriminant Analysis – Applied Multiple Time Throughout Process

Title 'Chapter 4 – Discriminant analysis;

data discriminant;

input product \$ country \$ Success b c d e f g h I j k l m n o p q r s t u v w x ZZ;

cards;

[DATA]

;

proc reg data = discriminant out=outQ anova manova;

class success;

var b c d e f g h I j k l m n ZZ ;

run;

Variable Reduction for Modeling – for All Attributes and ratios to determine all Models

Title 'Chapter 4 – Create all possible models;

data allmodels;

input product \$ country \$ Success b c d e f g h I j k l m n o p q r s t u v w x zz

ratioA = r/p;

ratioB = z/p;

[ratios cont.];

cards;

[DATA]

;

proc varclus data = allmodels;

var b c d e f g h I j k l m n zz ratioA ratioB;

run;

PHREG, survival procedure – for attributes and ratios limited down from the variable reduction model

Title 'Chapter 4 – Reduce all possible models created;

data reduceallmodels;

input product \$ country \$ Success b c d e f g h I j k l m n o p q r s t u v w x

ratioA = r/p;

ratioB = z/p;

[ratios cont.];

cards;

[DATA];

proc phreg data = reduceallmodels;

model success = b c d e f g h I j k l m n ratioA ratioB ...

/selection=score best=5;

run;

"SUCCESS IS A JOURNEY, NOT A DESTINATION." – BEN SWEETLAND