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PRODUCTION AND EVALUATION OF A NOVEL HIGH-PROTEIN PRODUCT

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ABSTRACT

Traditional approaches to making healthier frozen desserts have focused on decreasing the number of ingredients perceived as being unhealthy or the overall portion size of the product, rather than increasing beneficial nutrients. In this study, the potential to create a high-protein freezer popsicle to bridge the gap between frozen confections and protein supplements is examined. A formula and pilot-scale production process were developed to package the popsicle in a low density polyethylene (LDPE) tube, and a large-scale sensory evaluation study was completed (n=140). Upon compositional analysis, it was determined that the popsicles delivered 22.44 grams of protein in a 100 gram serving size. The results from sensory study participants were positive, with an average liking of 6.32 on a 9-point hedonic scale. Overall, participants found the number of calories, protein content, and flavor in the product to be just-about-right, however concern was expressed over the number of added calories and the packaging.

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Chapter 1

Literature Review

Current Consumer Trends

High protein beverages, powders and bars are mainstream products in the vitamin and supplement industry, with protein powder alone making up 13.2 percent of this $17.7 billion industry (Yucel, 2015). The mainstreaming of "high protein" versions of popular products reflects the current consumer trend toward eating diets where a proportionately higher amount of calories come from protein. This may be due to the fact that other macronutrients—fats and carbohydrates—have received negative attention in the lay press. Specifically, popular diets such as the Atkins weight loss diet have vilified carbohydrates (Astrup, Larsen, and Harper, 2004) much in the same way that fat-free versions of products have given consumers the impression that fats need to be avoided (Weinberg, 2004).

Currently, 34 percent of nutritional and performance drink users consume them when they are not working out (Bloom, 2015). The appeal of products that provide nutritional supplementation has transcended the traditional market for athletes. Many consumers are looking for healthier alternatives to traditional products. Sales in traditional product categories have experienced plateaus, while sales are increasing for products that offer increased nutritional benefits.

In the category of ice cream and frozen novelties, sales have been stagnant recently. Almost a third (29%) of consumers are buying less frozen treats than they were a year ago, and almost half (48%) said this was because they considered frozen treats to be "unhealthy" (Bloom, 2014).

Clearly, there is a need for healthier frozen treats that will satisfy consumers' desire for ice cream like products, but which deliver a healthier nutrient profile. Consumers still want products that have the flavor and "indulgence factor" of traditional desserts, but they have become less willing to make a trade-

off in terms of their health (Cawley, 2004). Companies have started to take notice. In February 2015, the Polish company Vitalia released a probiotic-based weight-loss supplement, which is being marketed as a 'dessert replacement.' The idea behind products such as this is to create products that consumers want to eat which will also be beneficial, instead of the traditional approach that consumers should eat less of unhealthy products and more of healthy foods.

The purpose of this study is to evaluate a product concept that will address a gap in the current market. Consumers who are being conscious of their health have few options when looking to consume frozen treats. In particular, a segment of consumers who would benefit greatly from having the option to consume a high-protein frozen product is gym-goers who are looking to increase their protein intake after a workout. The high protein freezer popsicle investigated in this study would address this disconnect between consumer need and what is currently available.

Sources of Protein

There are several sources of protein that are currently being used for protein supplementation. Whey and casein are two dairy proteins that are extremely common sources of protein in sports nutrition supplementation (Campbell, et al., 2007). Egg protein is also frequently used, and soy protein provides a common vegan alternative to dairy and egg proteins (Campbell, et al., 2007).

Different protein sources have differing degrees of bioavailability and amino acid composition. Bioavailability is the amount of protein that is absorbed by the body in comparison to the amount that is ingested and is often expressed as a percent of total protein released from the material during in vivo digestion (Stodolak and Starzyńska-Janiszewska, 2008). This can vary based on the protein source, but protein that comes from animal sources typically has higher bioavailability (Tang J. , Moore, Kujbida, Tarnopolsky, and Phillips, 2009). Unheated milk proteins have almost 100 percent digestibility, making them an excellent source of protein (Gropper and Smith, 2012). Additionally, the amino acid composition

of the protein is also very important for its biological function once it is absorbed. While the human body can produce some of the amino acids that it needs, some cannot be synthesized in the body and must be consumed from the diet. These proteins are considered essential (Børsheim, Tipton, Wolf, and Wolfe, 2001). Complete protein sources have all of these essential amino acids. Whey proteins are high in the sulfur-containing cysteine and methionine amino acids while casein is relatively high in tyrosine and phenylalanine (Tang J. E., Moore, Kujbida, Tarnopolsky, and Phillips, 2009).

In this study, whey proteins were identified as the optimal protein source over other alternatives due in part to their being highly recognizable by the target consumers and for their combined host of functional properties such as solubility in water, heat stability, nutritional value and water binding (Zemel, 2003). Additionally, whey protein offers numerous nutritional advantages over other commonly used protein sources. Whey protein is very rapidly absorbed by the body (Tang J., Moore, Kujbida, Tarnopolsky, and Phillips, 2009), which makes it ideal for consumers interested in muscle accretion by combining exercise with a high protein diet. When consumed after exercise, a whey protein and carbohydrate beverage has been shown to stimulate muscle protein synthesis (MPS) when compared to a beverage containing carbohydrates alone (Tang, et al., 2007). Whey protein was found to be a superior protein source for stimulating MPS in young men (Tang, et al., 2009). Researchers concluded this might be due to the rate at which the proteins are digested, or it could be due to differences in the leucine content of each protein. They also noted that the "slow" absorption proteins such as soy and casein seem to primarily inhibit muscle breakdown while "fast" absorbed proteins such as whey seem to be involved with stimulating a rise in muscle synthesis.

In addition to athletes and body builders, there are other groups such as children, pregnant and elderly people who should also be consuming more than the 0.8g protein/kg body weight, which is recommended for the general population (Campbell, Crim, Dallal, Young, and

Evans, 1994). In such applications, whey protein has also been established to be more effective. Researchers (Pennings, et al., 2011) found that whey protein was a more effective stimulator of muscle accretion than casein and hydrolysate in men ranging in age from 73-75. Additionally, other work (Tang J. , Moore, Kujbida, Tarnopolsky, and Phillips, 2009) found that whey proteins promote greater muscle synthesis than do soy proteins.

Dairy Proteins

Protein in milk can essentially be split into two fractions, of which about 80 percent is casein and 20 percent is whey protein. Both of these protein fractions are heterogeneous mixtures of several types of protein. Whey protein consists primarily of β-lactoglobulin, α-lactoglobulin, bovine serum albumin and immunoglobulins, as well as some other minor protein fractions such as lactotransferrin and enzymes (Mulvihill and Ennis, 2003). These globular proteins (discussed later in greater detail) have tertiary structural conformations that make them prone to denaturation upon heating. Casein proteins are typically found in micelle arrangements that are comprised of calcium phosphate with four different peptide chains: α_{s1}, α_{s2}, β, and κ. These are contained in micelles in the ratio of 11:3:10:4, respectively (Walstra, Wouters and Geurts, 2006). Casein proteins have a high degree of heat stability because they typically have only one structural conformation and therefore cannot denature easily.

Different types of proteins have differing degrees of solubility in water. Whey and casein protein concentrates have relatively high hydration capacities in comparison with other potential sources of protein. Commercial preparations of whey protein concentrates have hydration capacities between 0.45-0.52 grams of water per gram of protein and sodium caseinates can range from 0.38-0.92, while soy protein commercial preparations have hydration capacities around 0.33 grams of water per gram of protein (Kuntz and Kauzmann, 1974).

Casein proteins are hydrophobic and stay in solution in part by associating with other hydrophobic molecules and through association with other casein molecules and in part through having a high charge due to many prolines, phosphate groups and few cysteine residues. This circular shape is called a micelle (Bingham, 1971) (Kumosinski, King, and Farrell, 1994). A unique property of casein molecules is that they have little secondary and tertiary structure, which means that they cannot readily be denatured. Therefore, casein remains soluble when heating at temperatures below 100°C (Walstra, Wouters and Geurts, 2006). Sodium caseinates have been found to be heat stable at 140°C for 15 min. at a pH of 9 (Modler, 1985). Other sources (Mulvihill and Ennis, 2003) state that sodium caseinate will not coagulate in water for 60 min at 140°C.

Caseins also have unique interactions with calcium ions. κ-casein is not sensitive to the presence of calcium, however, the α_{S1}, α_{S2} and β-caseins are insoluble in the presence of Ca^{2+} because they have undergone post-translational phosphorylation, causing them to form anionic clusters. When Ca^{2+} binds to these clusters, it causes this region to become dehydrated and uncharged, thus changing the ratio of hydrophobic interactions and electrostatic repulsive forces. The location of polar and hydrophobic residues around the molecule allows the caseins to associate and form micelles. β-caseins in particular are the most hydrophobic casein, having only a small 21-residue N-terminal polar domain in comparison to the rest of the molecule, which is relatively hydrophobic (Damodaran, Parkin and Fennema, 2008).

The predominant proteins in whey are β-lactoglobulin and α-lactoglobulin, which have an overall negative charge at the pH of milk. Since these proteins have a relatively uniform distribution of hydrophobic, polar and charged moieties, they fold in on themselves relatively tightly so that interactions with other molecules are not common. Whey proteins, the β-lactoglobulin fraction in particular, will form a gel around 71°C (Hollar and Parris, 1995). Upon denaturation, this β-lactoglobulin portion will have a decreased amount of solubility, however the β-lactoglobulin can bind to the micellar κ-casein to cause increased heat stability (Bryant and McClements, 1998).

Colloidal Behavior

Proteins are amphiphillic molecules that can exhibit either acid or base properties depending on the pH of the dispersion. At pH values close to the protein's isoelectric point, the protein molecules will have a neutral charge and will interact with other protein molecules and can aggregate. As the pH moves away from the protein's isoelectric point, however, more of the side groups will become either positive or negative, resulting in a greater charge on the molecules. The like-charged protein molecules will repel each other and will be able to bind more water because of their increasing polarity, resulting in increased solubility (Pelegrine and Gasparetto, 2005). Thus, maximal whey protein solubility in water can be achieved by maximizing the difference between the product's pH and the protein's isoelectric point. This theoretical relationship has been experimentally confirmed in 18 percent concentration whey protein solutions where maximum turbidity and aggregate sizes was observed at a pH of 5.2, the isoelectric point of whey proteins (Ju and Kilara, 1998). At the pH of milk, both whey and casein proteins have a slight negative charge.

Low molecular weight additives can have a great effect on the stability of proteins in aqueous colloidal dispersions. Though some small molecules (urea or guanidine hydrochloride) have a destabilizing effect on proteins in solutions, sucrose and certain salts (such as NaCl) can elevate the thermal denaturation temperature of the protein (Damodaran, Parkin and Fennema, 2008). The stabilizing effect is believed to occur because the small molecules are only marginally attracted to the protein so they are found in greater concentrations away from the proteins. This creates an osmotic pressure that forces more of the solvent to be in closer proximity to the protein (Damodaran, Parkin and Fennema, 2008). NaCl can neutralize the charge at the surface of whey proteins, which has the effect of increasing the solubility of the β-lactoglobulin fraction of whey protein (McCord, Smyth, and O'Neil, 1998).

With increased temperature, the water binding ability of proteins typically decreases as hydrogen bonding decreases causing decreased hydration of ionic groups until the protein denatures which allows a roughly 10% increase in hydration capacity. These effects do, however, depend on the specific protein.

If the protein molecules aggregate, however, this effect is negated and the protein may become less soluble (Damodaran, Parkin and Fennema, 2008). It is also worth noting that whey proteins typically foam under agitation at concentrations of 2-5 percent (Damodaran, Parkin and Fennema, 2008).

Due to their amphiphillic nature, the proteins can aggregate at the water-air interface with the nonpolar residues facing the gas phase and the polar residues oriented toward the aqueous phase. When proteins are given the opportunity to aggregate in this space, particularly under high-speed mixing, the result is an increased incorporation of air into the product, which can result in foam formation (Foegeding, Davis, Doucet, and McGuffey, 2002).

High mechanical shear can cause protein denaturation and precipitation. When a 10-20 percent whey protein solution at pH 3.5-4.5 and at 80-120°C is subjected to a shear rate of 7,500-10,000/s, the result is the formation of insoluble spherical macrocolloidal particles (Damodaran, Parkin and Fennema, 2008). Since partial heat denaturation will increase the protein's ability to form a gel (Damodaran, Parkin and Fennema, 2008), it is ideal for minimal agitation to take place after the mix is heat processed.

Stabilizers

Non-gel-forming hydrocolloids have been established as inhibitors of the formation of elongated ice crystals in frozen desserts and preventers of growth in crystal size at low temperatures in abusive storage systems that include temperature fluctuations (Fernandez, et al., 2007).

Guar gum is formed from the ground endosperm of guar beans. The main polysaccharide in guar gum is a galactomannan called guaran. Guar gum is typically used as an economical thickening agent in combination with other gums. In ice cream production, it is typically combined with carboxymethlcellulose, carrageenan and locust bean gum (Cottrell, Pass, and Phillips, 1980).

Locust bean gum (LBG), or carob gum, is similar to guar gum. Also the product of a ground seed's endosperm, the LBG galactomannan is comprised of a galactomannan with fewer branches and a

more irregular structure than guaran, which includes long sections of underivatized D-mannosyl units (Sutherland, 1992). These long stretches without branches allow for LBG to form junction zones, allowing it to interact with the helical structures of xanthan and carrageenan (discussed later) leading to more rigid structure (Damodaran, Parkin and Fennema, 2008). Typical applications of LBG are similar to guar gum, with about 85 percent of LBG produced being used in dairy and frozen dessert applications (Doublier and Launay, 2007).

Xanthan Gum is a commercially produced polysaccharide based on xanthan, a heteroglycan produced by bacteria *Xanthomonas campestris*. Its polysaccharide backbone is the same as cellulose. When this structure is combined with the anionic trisaccharide side chains found on xanthan gum, the result is for the molecule to be quite stiff through these interactions. This structural rigidity is probably responsible for many of the stabilizer's unique functional properties (Chaisawang and Suphantharika, 2005).

Xanthan has multiple properties that make it well-suited for usage as a food gum. It has a high solubility in water at a wide range of temperature even at relatively low concentrations which means the effect it has on the viscosity of a solution is relatively constant from temperatures of 0-100°C. It is a very strong stabilizer of aqueous dispersions, suspensions and emulsions, and in particular, it imparts stability to products that are exposed to freezing and thawing. In combination with LBG, xanthan gum forms gels. When combined with guar gum, it can act synergistically to produce an increase in solution viscosity (Chaisawang and Suphantharika, 2006).

Carageenans are a group of sulfated galactans that are extracted from red seaweeds. There are three main conformations that make up the unit structures seen in the polysaccharide chains in carrageenan mixtures: kappa (κ), iota (ι), and lambda (λ). These may be blended or sold individually, with the predominant forms of carrageenan present dictating the behavior of the stabilizer blend. κ-carrageenan and ι-carrageenan have double-helical conformations much like the structure of xanthan gums, resulting in the occurrence of gelation in water at concentrations as low as 0.5 percent. These gels

can be prone to syneresis, but this process can be slowed if other stabilizers are present in the mix (Damodaran, Parkin and Fennema, 2008).

Specifically, carrageenan is able to form gels with dairy proteins. The thickening effect of κ-carageenan is five times stronger in milk than it is in water (Damodaran, Parkin and Fennema, 2008). Often, this thixotropic gel structure is used in the thickening of chocolate milk to prevent the settling of cocoa particles. κ-carrageenan can have a synergistic effect with LBG, with the combination of the two producing gels with greater elasticity and gel strength that have increased resistance to syneresis over the gels formed by κ-carrageenan by itself.

Flavoring

Cocoa powder is produced from the roasting of cocoa beans (Minifie, 1989), while vanilla extract is typically produced by extracting flavors from vanilla beans in an alcohol solution. Vanillin-relate substances have been determined to modify the flavor of products, resulting in increased smoothness, richness, and creaminess flavor sensations in foods such as ice cream which are particularly sweet or have a high fat content (Damodaran, Parkin and Fennema, 2008). In a previous study that aimed to create a whey-based, high-protein beverage, a 2 percent concentration of cocoa powder was used for imparting desirable color and flavor (Sinha, et al., 2007).

In this study, vanilla and chocolate flavoring will be investigated using cocoa powder and vanilla extract because these are the two most common flavors for high-protein popsicles and to establish a proof of concept which could eventually have further flavor extensions.

Thermal Processing and Packaging

Pasteurization is a process that destroys all vegetative, disease-causing pathogens in addition to many spoilage organisms by elevating the temperature of the product. In milk, this process occurs by elevating the temperature to 145°F for 30 minutes (International Dairy Foods Association, 2015). Different variations of this process can achieve the same end result by varying the time and temperature to which the product is exposed. This results in an increase in shelf life as long as the product is maintained at refrigerated temperatures to prevent spore growth. Commercial sterilization, however, destroys all pathogenic and toxin forming organisms. All spoilage organisms are destroyed that could grow under normal storage conditions, but the product needs to be maintained at storage temperatures under 140°F (Nelson, 2010).

In this study, heat treating to a degree higher than pasteurization, though not sufficient to be considered commercially sterilized will be investigated in order to establish a methodology for manufacturing the product that would allow it to be sold with frozen distribution. Consideration is also given, though not experimentally tested, to how a commercial sterilization process could affect this product.

Chapter 2

Hypothesis and Objectives

The hypothesis of this study is that it is possible to create a freezer popsicle that has acceptable sensory characteristics and contains at least 20 grams of protein per serving. The overall objectives of this study will therefore be to develop a consumer-acceptable freezer popsicle that contains at least 20 g of protein. After identifying a successful formula, production plan, and package, the product will be manufactured at the pilot scale level and will be evaluated through a large-scale sensory study to evaluate the product concept and determine what changes can be made to the product to make it more appealing to consumers.

Chapter 3

Materials and Methods

Initial Formulation

An initial formulation was determined by calculating the amount of whey protein concentrate needed to reach a goal of 20 grams per 100 gram serving size, and by estimating the proportions of the other amounts of ingredients. This was refined though limited taste tests to create the formula shown in Table 3-1. This mix was packaged in a 1 ½" diameter LDPE tube. After testing several recipes and the addition of guar gum as a stabilizer, the recipe in Table 3-2 was developed. Chocolate flavored product was used in the sensory study because the bitterness of the chocolate seemed to create a better flavor profile than the vanilla extract alone. Table 3-3 shows the calculated formula for the recipe used in the sensory study.

Table 3-1: Ingredients in the initial recipe for the product.

Ingredient	Amount (g) / 100g
WPC (78%)	25.55
Sugar	20.02
Water	53.42
Vanilla Extract	1.00

Table 3-2: Final recipe that was used in the sensory study for an individual 100g popsicle. Also shown is the amount that was used to produce the product for the sensory study.

Ingredient	Amount (g) / 100g	Total used in Production (g)
WPC (78%)	25.521	4466.18
Sugar	20.02	3503.5
Water	51.907	9083.73
Vanilla Extract	1.00	175
Cocoa Powder	1.00	175
Guar Gum	0.552	96.6
Total	**100**	**17500**

Table 3-3: Calculated formula for the protein popsicle.

	Protein (%)	Moisture (%)	Solids (%)	Fat (%)
Calculated Value	20	54.4	45.6	0.232

The source of whey protein used in this study was Jarrow Formulas Brand unflavored whey protein concentrate. Hershey's unsweetened cocoa powder (not processed with alkali) was used to impart the chocolate flavor to the product. Pure vanilla extract was used from McCormick, containing vanilla bean extractives in water and alcohol (41%). Reverse osmosis water was used to add moisture to the product. Domino pure granulated cane sugar was also included in the recipe. Guar gum was sourced from Bob's Red Mill.

Pilot-Scale Production Process

The flow diagram shown in Figure 3-1 was established in order to create a dependable way to consistently produce the product mix and place it into tubes. The following list explains the steps in this flow diagram.

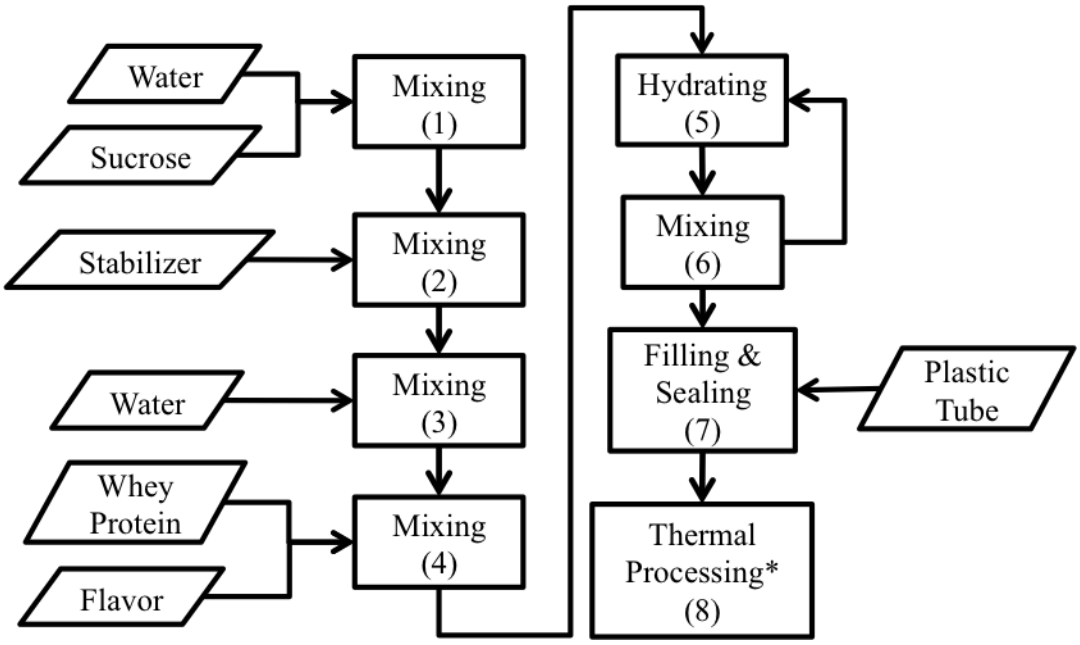


Figure 3-1: Flow diagram depicting the process that was developed to consistently create mix and manufacture popsicles up to 1 kg total popsicles.

1) Sugar was combined with an appropriate amount of water to create a 67% sucrose solids solution. The solution was mixed until the sucrose was completely dissolved. This will allow for maximal stabilizer solubility in the next step (Marshall and Arbuckle 1996). All mixing was performed using a kitchen aid mixer on the lowest mixing speed setting in order to minimize the surface interactions between the air and protein to minimize foaming.
2) Guar gum was added while the mixer was mixing on low speed for 45 seconds.
3) Water was then be added to the solution and mixed for 15 seconds.
4) Whey protein and flavoring were added to the mixture. After the protein was added, it was determined to be extremely important to minimize both the time and shear rate of mixing so that the protein will not have the opportunity to form a foam. Mixing occurred for 45 seconds.
5) The mix was then allowed to rest without agitation for 5 min. intervals to give the protein a chance to hydrate. The total amount of time for this step was equal to 45 minutes.
6) The product was mixed for 5 seconds, every 5 minutes for a total of 10 repetitions, or 45 minutes.

7) The product was then filled into a low density polyethylene tube and impulse sealed to form a package.
8) Next, the sealed tubes were thermally processed by submerging the product in a hot water bath for a period of 35 minutes maintained at temperatures between 65℃ and 70℃.

In order to scale up the production for to produce the 163 popsicles that were made for the sensory study, several modifications were needed to the initial flow diagram. A discussion of the changes can be found in the discussion section, while the changes are listed here. Instead of using a kitchen-aid mixer, a large immersion mixer was used. Clumps of protein were dispersed by grinding it between a large spoon and a strainer to allow hydration. Additionally, a milk pasteurization vat was used to heat the popsicles with steam.

Compositional Analysis

Compositional analysis was completed on the product to determine how close the calculated values were to the experimentally created popsicle. Protein was analyzed using a CEM SPRINT rapid protein analyzer machine set for milk protein concentrate. The sprint machine uses a protein-tagging technology which attaches to the protein itself, rather than measuring nitrogen in methods such as Kjeldahl or Dumas. By automatically adding a known amount of tracer to the sample, the amount bound is measured and converted to protein concentration (CEM Corporation, 2015). Fat was analyzed using a CEM Smart Trac II Magnet machine, which uses nuclear magnetic resonance (NMR) technology to measures the signal generated by hydrogens which it analyzes to determine the fat content. Moisture was analyzed by using a CEM Turbo Smart 5 machine in the “ice cream” setting. This machine heats the sample until it drives off water and the product has reached a constant weight. From subtracting the

starting weight from the final weight, it is possible to determine the amount of water and solids in the sample. All testing was performed in the Penn State Berkey Creamery's Dairy Testing Laboratory.

Sensory Evaluation Study

A large-scale sensory evaluation study (n=140) was conducted at the Penn State Sensory Evaluation Center for this experiment. Participants were principally recruited using an email screener which was sent to members of the Penn State Sensory Evaluation Center's sensory evaluation database. Additionally, some participants were recruited through flyers which were posted at local gyms, and some faculty and graduate students from the Penn State Food Science department were invited to take part in the study. Additionally, eight professional athletes from the State College Spikes baseball team took part in the sensory study, and completed the sensory evaluation on June 24, 2015. All other participants took part in the sensory study on June 26, 2015. The questions as they were presented to participants can be viewed in Appendix A.

The questions asked in the sensory study were varied in order to try to get a range of responses from participants. Participants were asked to evaluate their liking of aspects of the product such as sweetness and chocolate flavor using a 9-point hedonic scale in order to determine their liking of the product. The choices for the 9-point hedonic scale were "dislike extremely," "dislike very much," "dislike moderately," "dislike slightly," "neither like nor dislike," "like slightly," "like moderately," "like very much," and "like extremely." In order to determine why the participant liked or disliked the attribute, a 5-point just-about-right (JAR) scale and comment section were also presented to participants. A 5-point just-about-right scale allows participants to rate their preference on the amount of something. For example, the JAR scale for sweetness allowed participants to select between, "not nearly sweet enough," "not quite sweet enough," "just-about-right," "slightly too sweet," and "far too sweet."

Participants were also asked about their opinions on the products' nutrition facts panel. Specifically, participants were asked to evaluate the amount of added sugar, calories and protein. Participants were presented with a JAR scale to determine how they viewed the amount of the nutrient in the product. Participants were then presented with a 5-point concern scale which allowed them to show how much they cared about the nutrient in the product. The middle choice on the concern scale was "neutral." On either side, participants were presented with a space to click, but the choices were blank. On the extremes, participants could select either "not at all concerned," or "extremely concerned." For example, a participant might think that there are "far too many" calories in the product, but they might not care about calories. Using this method allows for analysis which takes into account whether it is worthwhile to make the change.

In order to determine whether participants liked the product's packaging, they were presented with a 9-point hedonic scale to determine how much they liked the product. Since a JAR scale is inappropriate to ask about packaging, a simple yes-or-no question was used to ask participants if the product was easy to open. Additionally, participants were given a comments section to comment on the packaging of the product so additional feedback could be collected.

Statistical Analysis

Statistical analysis was completed using Minitab 17 statistical software. The data was sorted into two groups after examining the study. Participants who "had tried" a high protein supplement prior to taking part in the study were put in the HT group while participants who "had not tried" a high protein supplement were placed in the HNT group. In order to perform statistical analysis on categorical data, numbers were assigned to the different categories that participants could choose from. For example, on a just-about-right scale, if a participant selected "just-about-right," it would be labeled as a 3. The averages from the two groups were compared using a t-test where p-values less than 0.05 were interpreted to

indicate that the null hypothesis could be rejected. Additionally, several analysis-of-variance tests were performed. Groupings were made based on confidence intervals and the results were further interpreted. The results from the statistical analysis can be found in Appendix B.

Chapter 4 Results

Compositional Analysis

The results of the compositional analysis are shown in Table 4-1 as are the values calculated using TechWizard. On average, samples contained 22.4 percent protein, and contained 51.52 percent water, meaning that they were on average 48.48 percent solids. Finally, the fat content was found to be 1.25 percent. Figure 4-1 shows a finished popsicle for the sensory analysis.

Table 4-1: Experimentally determined chemical analysis of the product. Data is shown with calculated mean, standard deviation, and confidence intervals.

	Protein (%)	Moisture (%)	Solids (%)	Fat (%)
Experimental Value Mean (SD)	22.44 (0.09)	51.52 (0.39)	48.48 (0.39)	1.27 (0.02)
Calculated Value	20	54.4	45.6	0.232
Difference	2.44	2.88	2.88	1.038

Figure 4-1: Popsicle produced for the sensory evaluation. A ruler is also included to show the scale of the popsicle.

Sensory Evaluation Study

Introduction

To aid with analysis, the data from the sensory evaluation study was analyzed in aggregate as well as in two subgroups. It was observed from a question in the survey that just over half (52.1%) of survey respondents had previously tried any kind of protein supplement. Therefore, two subgroups of data were created by selecting participants from the total pool of data based on their background with protein supplements. The group that "Have Tried" supplements (HT) was comprised of 73 participants, while 67 participants were placed in the "Have Not Tried" supplements group (HNT). The largest group was made up of All Participants in the survey (AP) and represents the collective responses of all 140 participants. This allowed for statistical analysis to be performed, which is presented in the discussion section.

Demographics

In total, 140 participants took part in the sensory study. Participants in the sensory evaluation ranged in age from 18 to 67. The average age of participants was 36. A breakdown of participants' age by category can be found in Figure 4-2. The gender of participants was an exact 40:60 split, with 40 percent male and 60 percent female participation, as shown in Figure 4-3. While the ratio of male to female participants was 40:60 in the AP group, this ratio was much more even (47.9:52.1) in the HT group. In the HNT group, female participants outnumbered male respondents by more than double, as shown in Figure 4-29.

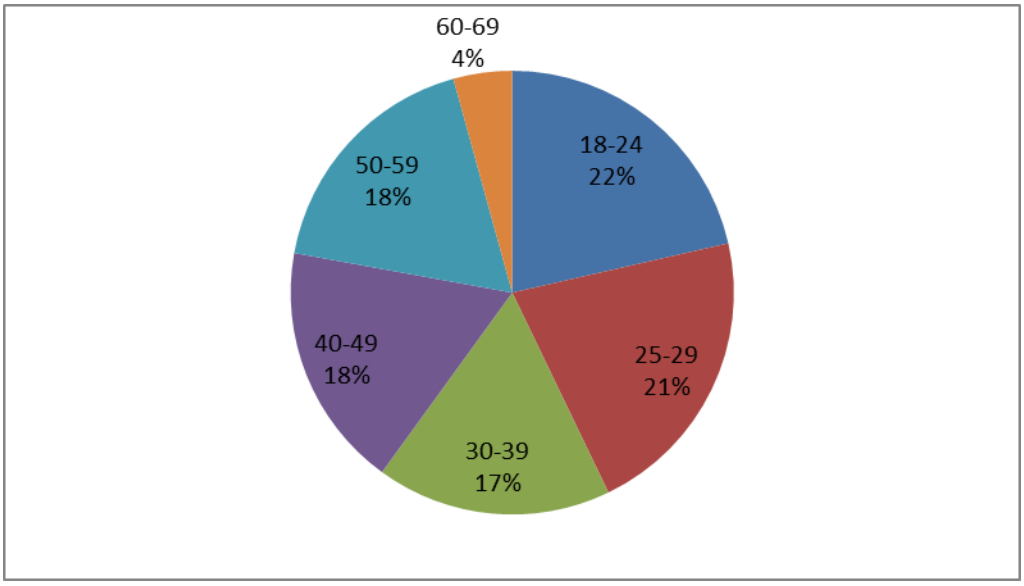


Figure 4-2: Percentages of participants who fall into the indicated age ranges. This data reflects all participants in the study.

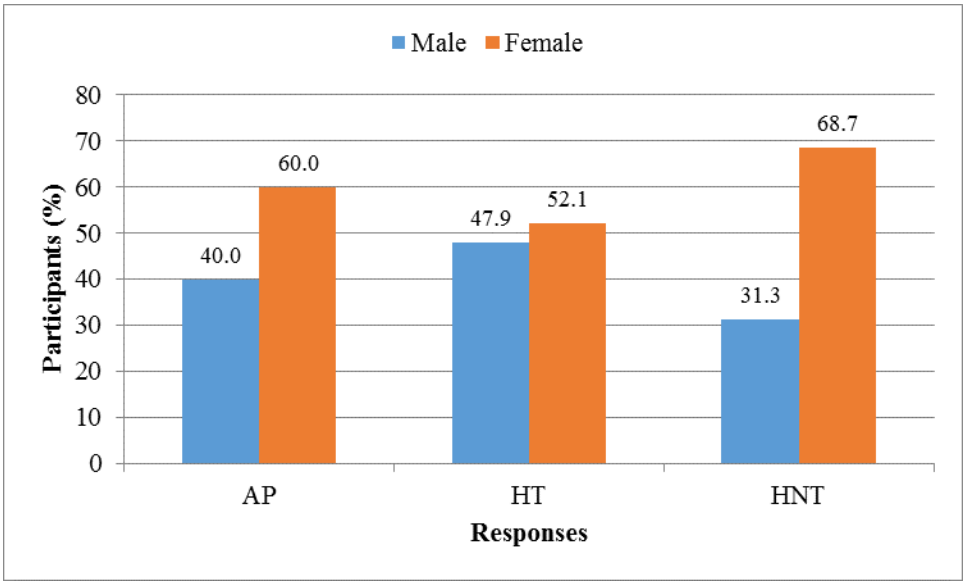


Figure 4-3: Shown are the results of asking participants to select their gender. An "Other/ prefer not to say" category was also given as an option for participants, however none of the survey participants selected this option. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they had previously tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

When asked how often they exercise, the majority of participants indicated that they exercise "multiple times per week," as shown in Figure 4-4. 58.9 percent of HT participants indicated that they exercise "multiple times per week," while 41.8 percent of the HNT group exercised at the same frequency. It was found that 25.4 percent of the HNT group exercised daily, while 19.2 percent of the HT group exercised that frequently.

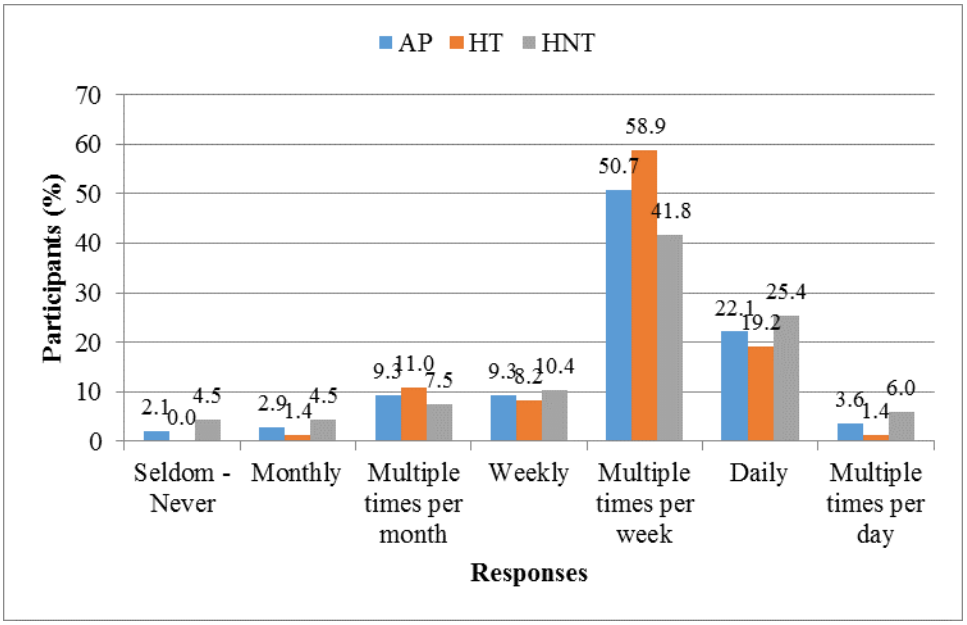


Figure 4-4: Shown are the responses of a question asking participants to indicate how frequently they workout. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they had previously tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

Participants were presented with a list of statements regarding their background with protein supplements (Figure 4-6). The statement, "I have tried some kind of protein supplement at least once," was used to split up the AP data into the groups of HT and HNT. Interestingly enough, 27.1 percent of the HNT group responded that they "consume protein supplements weekly," and 20 percent responded that they "consume protein supplements daily." Participants were also given statements regarding their background with athletics and instructed to select the

ones that most applied. The majority of AP (64.2%) played a sport in high school, as shown in Figure 4-5.

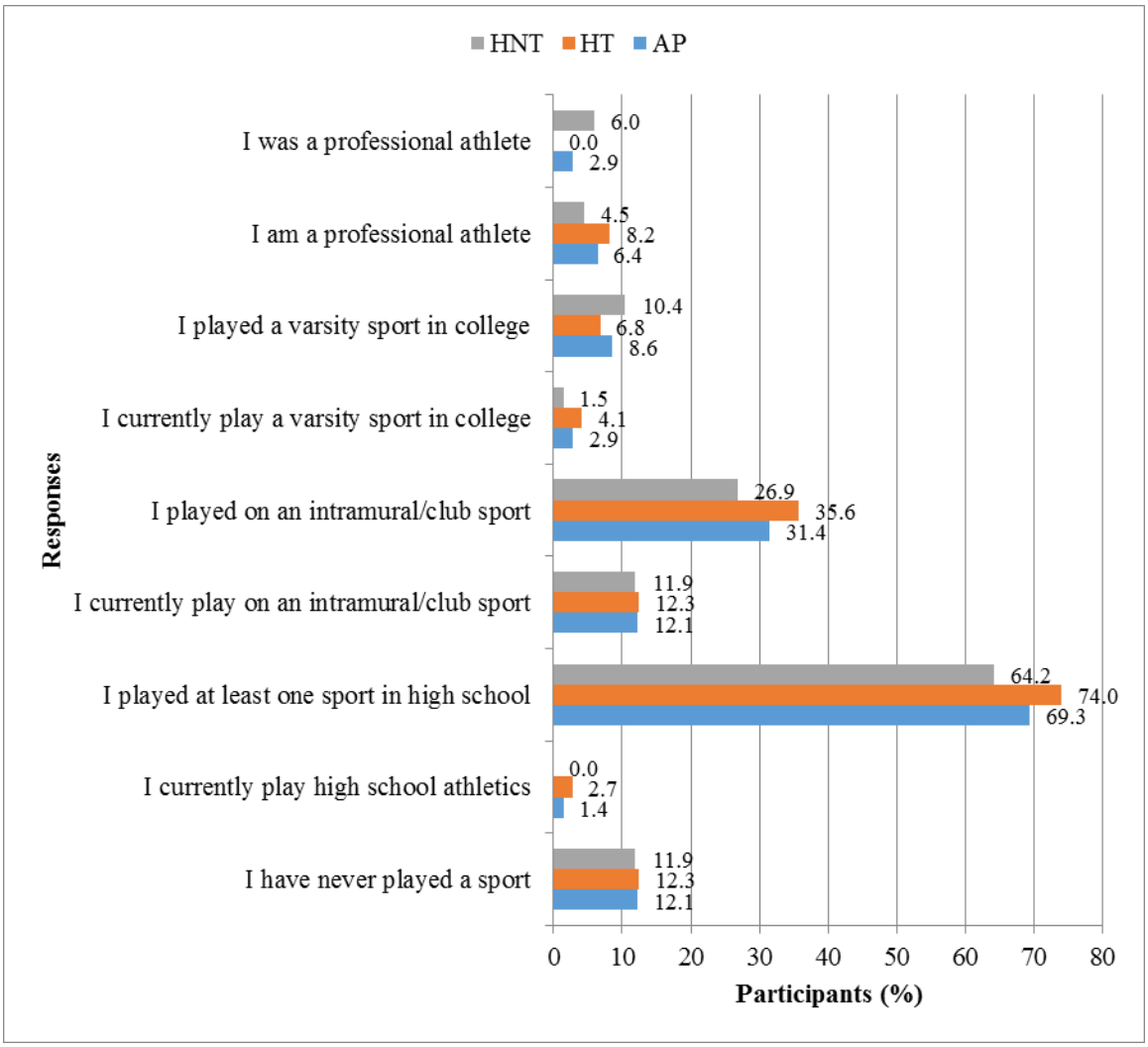


Figure 4-5: Results of asking participants to select all that applied with regard to their background with athletics. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they had previously tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

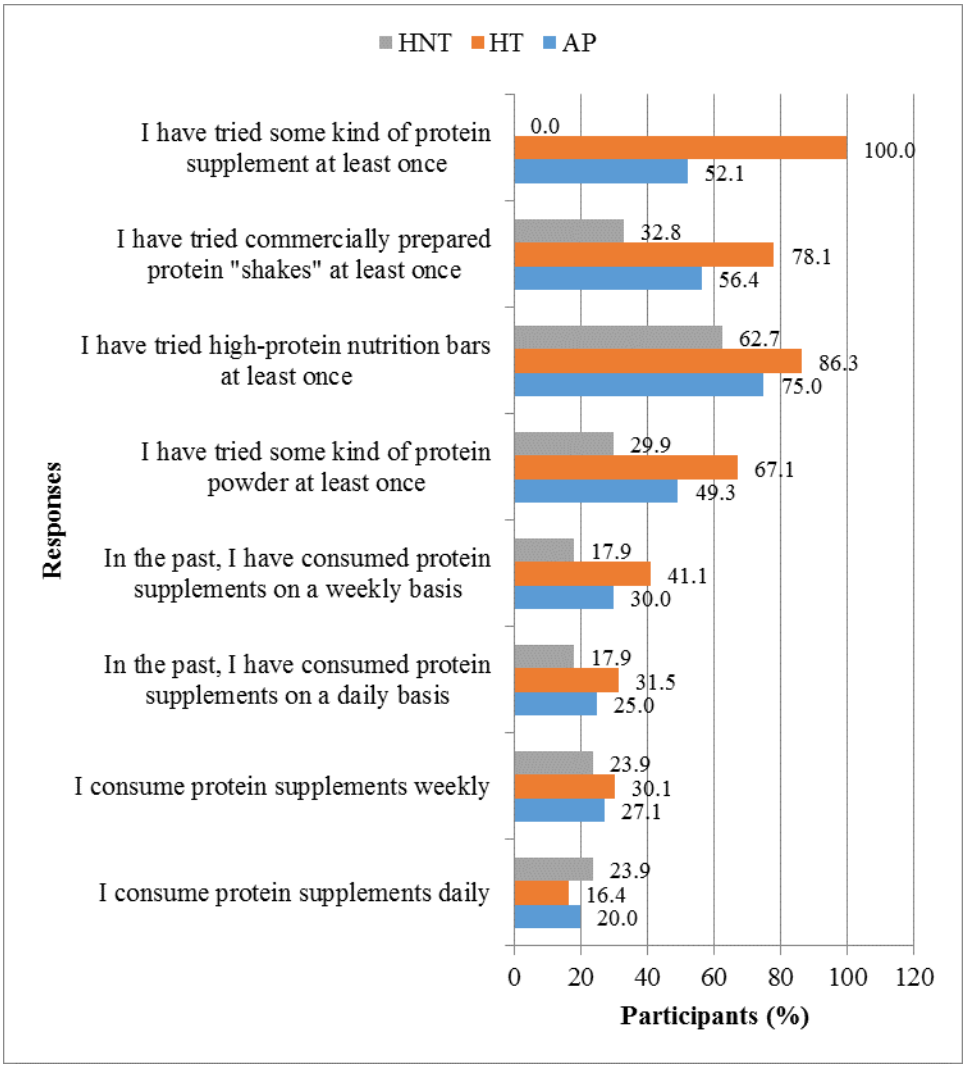


Figure 4-6: Results of asking participants about their background with protein supplements. The response, "I have tried some kind of protein supplement at least once" was used to split the data for analysis. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they had previously tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

Purchase Intent Comparison

Two questions were repeated before and after the participants had sampled the product. The questions were presented once after the participants had read a description of the product and again after the participants had sampled the actual product. The first asked participants to indicate their likelihood of purchasing the product on a 5-point scale ranging from "definitely

would not purchase" to "definitely would purchase." The second question was another five-point scale, which asked participants to rate how this product compares to other high protein products. The scale ranged from "much worse than other high protein products" to "much better than other high protein products."

Participants' likelihood of purchasing the product decreased on a whole after trying the product. Figure 4-7 shows AP data for participant's willingness to purchase the product before and after trying it. After reading only a description of the product, 58.5 percent of participants indicated that they either "probably would purchase" or "definitely would purchase" the product. After trying the product, this number decreased to 45 percent positive purchase intent. In the HT group, there was also a decrease in positive purchase intent, however it was less dramatic, moving from 57.5 to 52.1 percent positive purchase intent (Figure 4-8).

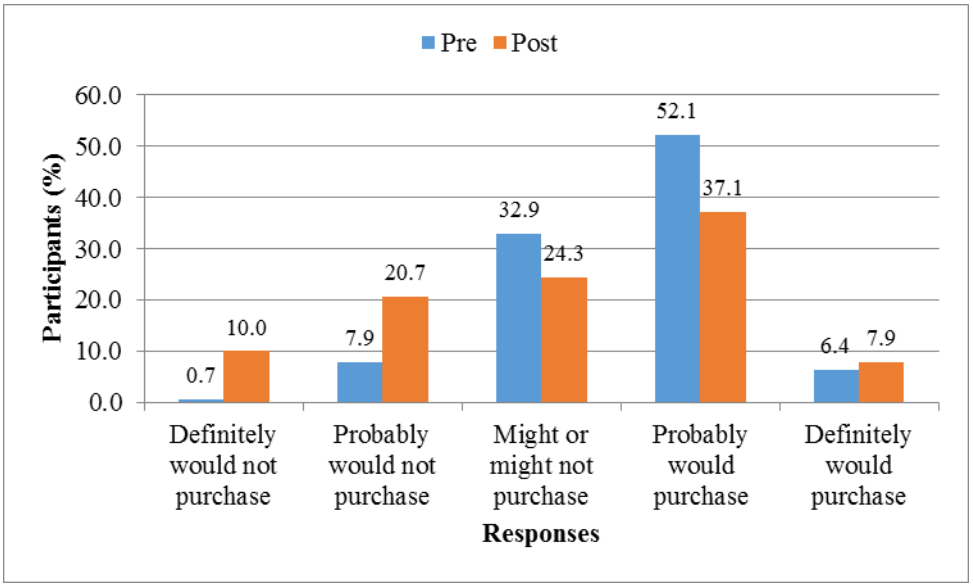


Figure 4-7: All participants' purchasing intent. This data represents the responses of all participants (n=140) in the sensory study when asked about their interest in purchasing this product. The "Pre" responses were collected after reading a short description of the product, but before having had the chance to sample it. The "Post" responses were collected after participants had been given the chance to sample the product.

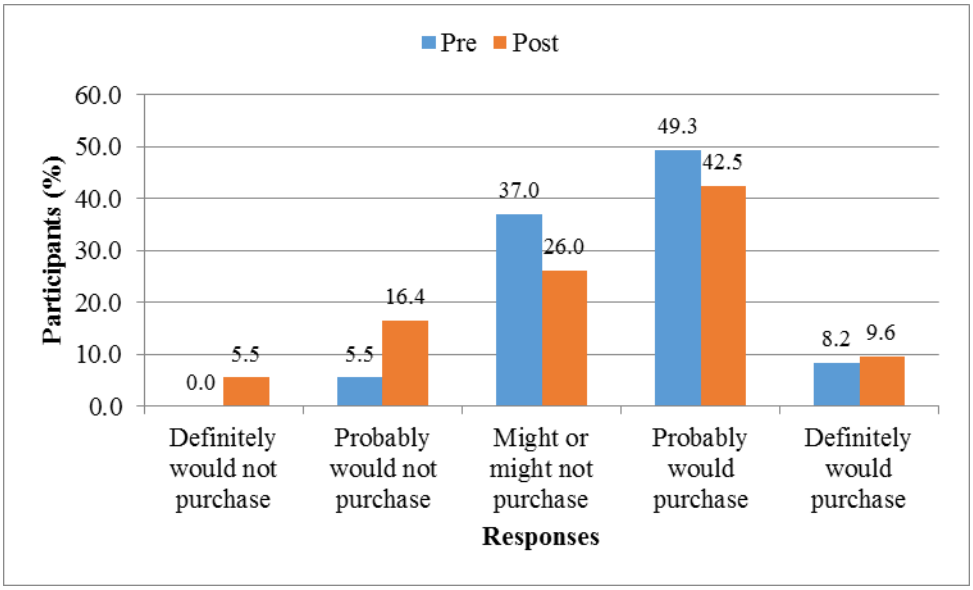


Figure 4-8: Purchasing intent for the subgroup of data who indicated they had previously tried high protein products (n=73). The "Pre" responses were collected after participants had the opportunity to read a short description of the product, but before being given the chance to sample it. The "Post" responses were collected after participants had been given the chance to sample the product.

When participants were asked to compare this product to other products, 44.3 percent of participants indicated that it was "about the same as other high protein products" before trying the high protein popsicle in this study (Figure 4-9). After trying it, however, the number that thought it was "about the same as other high protein products" dropped to 28.6 percent. After trying the product, the number of participants who thought the popsicle was "slightly worse" and "slightly better" than other products both increased. The number who thought the popsicle was "slightly worse" than other high protein products increased from 12.1 to 20 percent, while the number who thought the product was "slightly better" than other high protein products increased from 33.6 to 39.3 percent. Overall, after trying the high protein popsicle, 48.6 percent of study participants considered it to be "slightly better" or "much better than other high protein products." 28.6 percent of participants viewed it as "about the same as other high protein

products" and 22.9 percent thought it was "much worse" or "slightly worse than other high protein products."

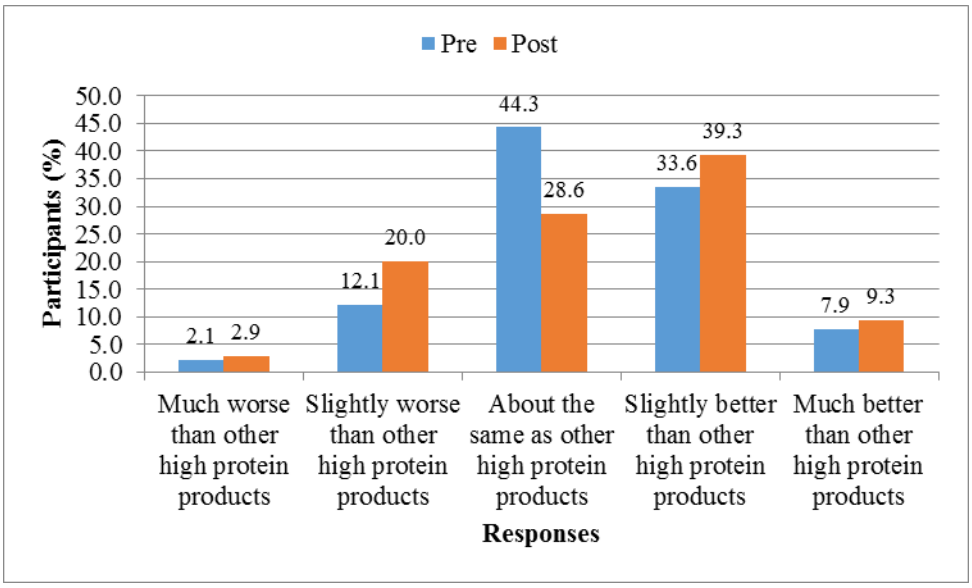


Figure 4-9: Results of asking all participants in the study (n=140) about their opinion on how this product compared to other products currently on the market. The "Pre" responses were collected after reading a short description of the product, but before having had the chance to sample it. The "Post" responses were collected after participants had been given the chance to sample the product.

After sampling the product, 58.96 percent of participants in the HT group thought this product was better to some degree than other high protein products currently available, while 13.7 thought it was worse (Figure 4-10). 27.4 indicated it was "about the same as other high protein products." A similar decrease in participants who felt the product was "about the same as other high protein products" that was observed in the AP group was also observed in the HT group. Interestingly, however, after trying the product, the shift in the number of participants was only to increase their opinions of the product. The number of participants in the HT group who felt the product was "much worse than other high protein products" stayed at 1.4 percent and the number who thought it was "slightly worse" stayed at 12.3%, while the number of

participants who thought the product was “slightly better” than other products increased from 37 percent to 47.9 percent after they had the opportunity to try the product. The number who thought it was “much better than other high protein products” increased from 4.1 percent to 11.0 percent. This information is presented in Figure 4-10.

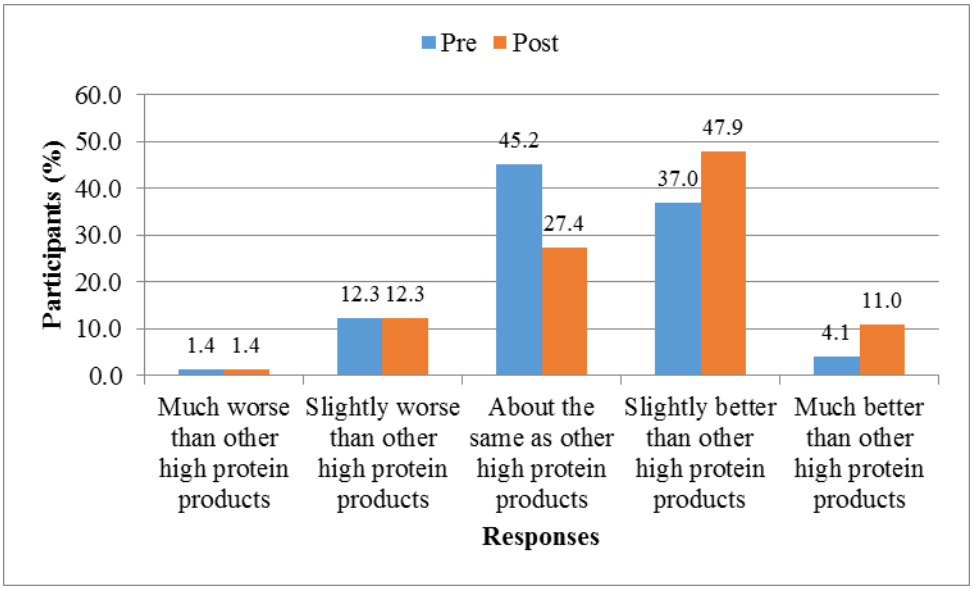


Figure 4-10: Results of asking the participants who previously have tried high protein products (n=73) about their opinion on how this product compared to other products currently on the market. The “Pre” responses were collected after reading a short description of the product, but before having had the chance to sample it. The “Post” responses were collected after participants had been given the chance to sample the product.

The data from the participants in the HNT group is presented in Figure 4-11. Before and after trying the product, 29.9 percent of respondents indicated that they thought the product was “slightly better” than other available products. After trying the product, the number of participants who thought the product was “slightly worse than other high protein products” increased from 11.9 percent to 28.4%. After trying the product, the data was roughly split into thirds between “slightly worse,” “about the same,” and “slightly better” than other protein products with 28.4, 29.9, and 29.9 percent respectively.

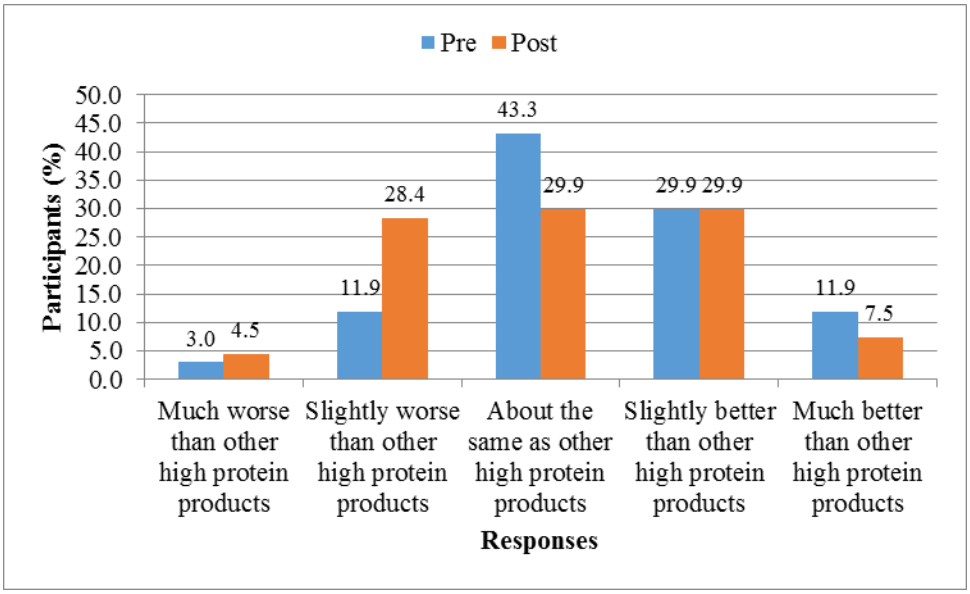


Figure 4-11: Results of asking the participants who previously have not tried high protein products (n=67) about their opinion on how this product compared to other products currently on the market. The "Pre" responses were collected after reading a short description of the product, but before having had the chance to sample it. The "Post" responses were collected after participants had been given the chance to sample the product.

Overall Liking

Looking at the AP overall liking of the product, it appears that the product was viewed favorably as participants evaluated their "overall liking" of the product to an average of 6.32 on a 9 point hedonic scale (Table 4-2). On the scale, this means that the average was between "like slightly" and "like moderately." The HNT group had a lower average overall liking of the product at 5.91, which indicates an average between "neither like nor dislike" and "like slightly." The HT group had an average of 6.69, which is higher than both the AP and HNT average, as shown in Table 4-3. Looking at the distributions by category for the HNT group (Figure 4-12), the data is relatively bimodal toward liking or disliking the product. None of the participants indicated that they "neither like nor dislike" the product, however 32.9 percent viewed the product unfavorably by selecting "dislike very much," "dislike moderately," or "dislike slightly." In comparison, 67.2 percent of participants responded favorably by choosing "like

slightly," "like moderately," or "like very much," or "like extremely." In comparison, only 13.7 percent of the HT group disliked the product, while 82.2% of this group liked the product to some degree.

Table 4-2: Averages of participants' overall liking of the product.

Group	Average Liking
All Participants (AP)	6.32
Have Tried Protein Supplements (HT)	6.69
Have Not Tried Protein Supplements (HNT)	5.91

Table 4-3: Percentages of respondents that gave negative, neutral, or favorable responses for overall product liking.

Group	% Dislike	% Neither like nor Dislike	% Like
All Participants (AP)	22.9	2.1	75
Have Tried Protein Supplements (HT)	13.7	4.1	82.2
Have Not Tried Protein Supplements (HNT)	32.9	0	67.2

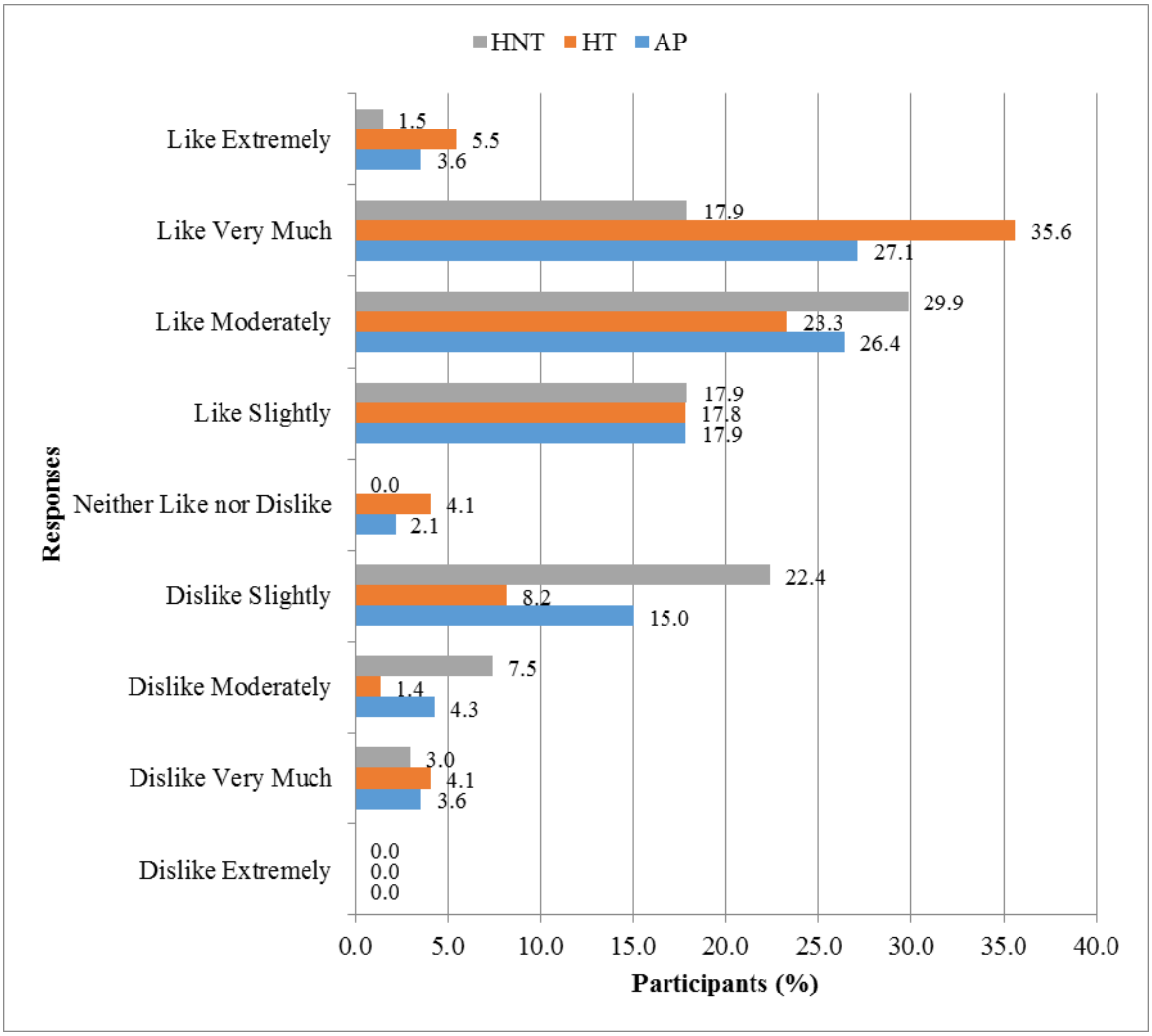


Figure 4-12: Participant responses indicating their overall liking of the product. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they previously have tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

Study participants were presented with a question which gave them a list of adjectives regarding the product and were instructed to choose all that applied, as shown in Figure 4-13. Few participants (8.9%) thought the product was grainy, and relatively few felt it was "fast melt." About a quarter of participants (23.6%) felt the product was "slimy." About half of participants thought the product was "slow melt," and "gummy," (45.0% and 47.1%, respectively). 57.1 percent thought the product was

"smooth" and 67.9 percent thought the product was "creamy." Participants were given the opportunity to comment on "any other" aspects which they felt had not been covered in the survey questions. The HT comments for participants who chose to comment are shown in Table 4-4. HNT comments for the same section are shown in Table 4-5.

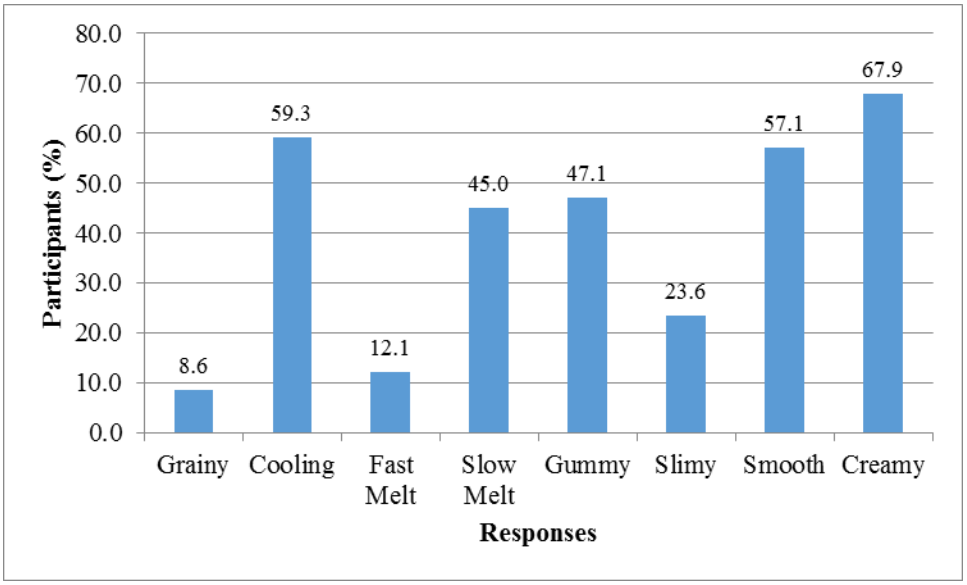


Figure 4-13: Participants responses who indicated that they felt the product did exhibit the suggested adjective. The results shown are from all participants in the sensory study (n= 140).

Table 4-4: Responses from participants who previously have tried high protein products (HT) when asked to give "any other thoughts" regarding the product. Only participants who gave responses are listed in the table. HT is a data set from only those panelists who indicated they previously have tried a high protein product (n=73).

Participant Number	Comments
psu33	nothing
psu75	if you can get the amount of sugar down, I would definitely buy this product!
psu1	Good tasting and doesn't leave a bad after taste. Not too sweet. Good consistancy
psu136	Great concept! A lot of people are looking for new high protein foods, so I think this would be something that should be developed further. It's an unfilled slot in the marketplace I think!
psu4	pretty quality product. I would buy it right now. little hard to get the bottom of the protein bar. maybe create slits that go down the tube so plastic can be torn off as you get lower on the product. GOODLUCK!
psu107	very good tasting product. once the packaging is improved, im sure it will be successful.
psu57	better then I thought it would be

Participant Number	Comments
psu5	it is very good just an easier way to consume would be nice.
psu8	none
psu73	Great product. Needs different packaging
psu80	Seems to have ice crystals in the product, which is undesirable. Leaves a heavy mouth coating. Packaging was not what I expected based on description.
psu98	I like the idea of a frozen protein product, especially as cooling protein source after a work out. However, the tube makes it difficult to eat compared to a protein bar or drink. if there is any way to aid the product in moving up the tube, that would be beneficial. Also, the sugar content is very high compared to the protein powder I use (Giant food store brand).
psu94	more chocolate flavor will be better
psu109	Slightly too high in sugar. Also curious about the calcium content since it contains milk.
psu72	Seems like a nice way to cool down after a workout. Also it appears to be a healthier than eating just straight ice cream. I suppose I would like a lower sugar content to make me feel less guilty of eating one post workout.
psu12	I think that an ice cream product that would offer impeccable macros for people closely watching their diet would be a hit on the market. I would recommend to be careful with the amount of sugar (no more than 10-12g per serving, maybe incorporate few poly-unsaturated healthy fats (Omega 3 easily marketable) and increase the amount of protein per serving to 25g.
psu74	The presentation and ease of consumption detracted from the product, but the product itself was surprisingly good for a high protein supplement.
psu137	For a snack like this, I did not expected to be high nutrient. Taste is most what I am concern. Probably other special customer would be the target.
psu138	It tastes as "slimfast" milkshake chocolate, I prefer royal chocolate of this brand. Maybe that flavor can be work better than this
psu50	taste much better than protein shakes
psu60	This product was very refreshing. I would look forward to enjoying it after a workout during the summer months. Unfortunately, I do not think that I would enjoy during the winter. Overall I was extremely pleased with the product, especially the taste and consistency.
psu62	very artificial tasting and with the high sugar content I wouldn't purchase
psu63	If you can somehow get rid of the gummy and sliminess of the product it would be perfect.
psu120	I think this is a cool idea to bring high protein snack in this frozen dessert form.
psu93	Surprisingly good and doesn't taste "protein-y." Would be interested in flavors like vanilla and strawberry more, but this was refreshing.
psu113	The creamy rich chocolate flavor makes it palatable for consumers not looking for a high protein product.
psu132	very good taste comparing to normal protein bars
psu91	this is neat, and would be a good product for athletes who finished a practice or a

Participant Number	Comments
	game outside.
psu97	Just wish I had another one. It's great!
psu30	I like the flavor of this, very good tasting for a protein product.
psu17	good flavor, slightly gummy, nice part about this product is that it is cold and refreshing. It is a bit difficult to squeeze the bottom part up through the tube once the initial bites are consumed
psu41	I was a little concerned by the sugar content and lack of dietary fiber and fat. I detected a slight artificial sweetener aftertaste. I strongly dislike artificial sweeteners and would prefer regular sugar if it was required for taste.
psu139	If the point is to make a recovery product after exercise, it might work but really isn't any better than yogurt or chocolate milk....
psu19	I like the texture and flavor, also I like that its frozen would be refreshing after a workout
psu37	convenient package, a little too much chocolate flavor, cut back on the sugar and carbs
psu49	product overall was just oK - it needs to not be too gooey, and "slimy" I guess. Could come out of the plastic a little easier.
psu42	it is really good - very yummy and satisfying!
psu18	as a trail runner I like the size of this item, it can fit into a waist pack or small back pack for a quick protein boost...
psu55	Packaging needs to be a little more glamorous.
psu29	I like the idea of a frozen treat as a way of getting protein
psu88	good taste and no bad after taste
psu10	I was surprised at how good the flavor and product was.
psu20	liked overall but just too sweet and not enough chocolate flavor
psu61	I liked the product, it just was too sweet for my taste.
psu89	very heavy yet does have a creamy texture to it
psu104	Overall a good product. I bike and use protein bars and other products. I think the protein value of this product is excellent, but it lacks on some other nutritional values that maybe could be included and is a little high on sugar content.
psu144	The presentation was offsetting, the chewiness/gumminess was too much melting in the mouth to a much too pasty thick slurry. I'd sooner drink cold protein drinks that eat this product... sorry
psu135	I have a lingering fat taste in my mouth, almost like it did not melt

Table 4-5: Comments from participants who previously have not tried high protein products (HNT) when asked to give "any other thoughts" regarding the product. Only participants who gave responses are listed in the table. HNT represents those participants who reported they have not tried a high protein product (n=67).

Participant Number	Comment

psu35	the texture is a bit weird, maybe too soft. but other than that the flavor is good. Maybe not as much sugar. If there were maybe 11g of sugar I would eat this often.
psu6	The flavor of the product is very good and helps put it slightly above other protein products which usually don't have a good taste. The packaging also makes it easy to eat while moving around.
psu7	Too difficult to access. Too much sugar.
psu141	The sugar taste weird, chocolate taste powdery, and too slimy.
psu2	Overall I really like it. Good flavor. Easy to eat. Not messy. Its a little bit thick but I can get over the thickness knowing its protein and good for me.
psu58	its good
psu64	I liked it better when it started to melt, also I think it's a great idea because it was more refreshing than a protein shake because it was so cool.
psu95	it contains a relatively large amount of protein, but it may be more healthy if the sugar is reduced
psu92	If it had a little less sugar, it would be better. The flavor and texture are really good !
psu100	conceptually, this is just not a great idea. It takes a lot of effort to consume the product. After a workout, I don't think I would want to put the effort into getting my protein that this product requires.
psu32	it's a bit chalkier than the typical protein shakes that I consume.
psu108	The gummy texture is a big turn-off. I have never eaten a popsicle with a gummy consistency like this.
psu142	It is a little bit too gummy. If it can be more creamy and with more milk flavor, I will definitely like it more. I like the idea of packaging.
psu143	I prefer it to be sweeter.
psu21	It tastes very good and is an awesome concept
psu99	easy too get sick of the chocolate flavor, too sweet
psu128	I think the product on a stick would be better and easier to consume
psu51	texture might be a dealbreaker, but it was otherwise pretty good
psu83	I like the idea, especially on a hot summer day, but it's not the easiest supplement to consume. I may or may not buy it, it really depends on price, availability, and the amount of protein it has. If this can be a complete post workout supplement it would definitely be easier than making a protein shake.
psu15	I think its too high in sugar
psu127	The product is too gummy and is very hard to melt in the mouth. After taste is not so good.
psu31	I think it's a brilliant idea.
psu81	really good idea for high protein product- nice change to your normal protein bar
psu56	It leaves a film in my mouth that is unpleasant. I likely wouldn't purchase this product because my current protein powder is much better tasting.
psu126	I think its little too sweet which might affect its value as healthy snack. It does look like good source of protein and dietary fiber so it can be made little less sweet.

psu122	Packaging killed this product for me.....was slightly to gummy as well.
psu22	great product, loved the flavor and texture. great way to get protein, with a sweet treat.
psu103	like that it is frozen but melts quickly
psu121	great concept and while I'm not a body builder, I could certainly see that it would be great after a work out
psu43	packaging is terrible. make into popsicle on a stick. more appealing that way. maybe is going for the gogurt look you should make packaging colorful not see through
psu25	It was not fake tasting and didn't have a strong artificial taste. Creamy and good .. not fake and gummy. I would purchase but I am not happy with sugar content. I like lower carbs in a 'high protein' product.
psu69	it would be very refreshing after a workout but I don't think I would want to deal with the packaging
psu105	Sugar is a known poison - and I would not knowingly purchase a product with this much sugar. Its totally ridiculous to market a product as a healthy-type food with the emphasis on high protein - and then slam it full of sugar!
psu78	did not like it
psu111	It would be good to have a product like this after a workout
psu44	Interesting concept. Can see athletes using this during two a days or other similar high temp workouts.
psu40	Artificial taste -- texture terrible, taste left bad aftertaste. Also bad packaging/

Participants were given a list of potential concerns with the product and were asked to select which of the listed concerns they had. This data is summarized in Figure 4-14. 47.9 percent of all participants indicated that they felt “the sugar content is too high.” This was very consistent across the groups. The HT had 11 percent of participants respond that they “didn’t like the taste” while 31.3% of the participants in the HNT group did not like the taste of the popsicles. Very few participants, only 3.6 of AP, felt that the “product does not contain enough protein.” The two groups of participants were very similar in percentage of respondents who “prefer other products currently available,” with 19.2 percent and 23.9 percent of the HT and HNT respondents feeling this way, respectively. Very few participants indicated they were not interested in consuming more protein (5.7 % of all participants). Participants were also given the option to input other concerns they might have in an “other” section. The comments which were given by participants in the “other” section are shown in Table 4-6.

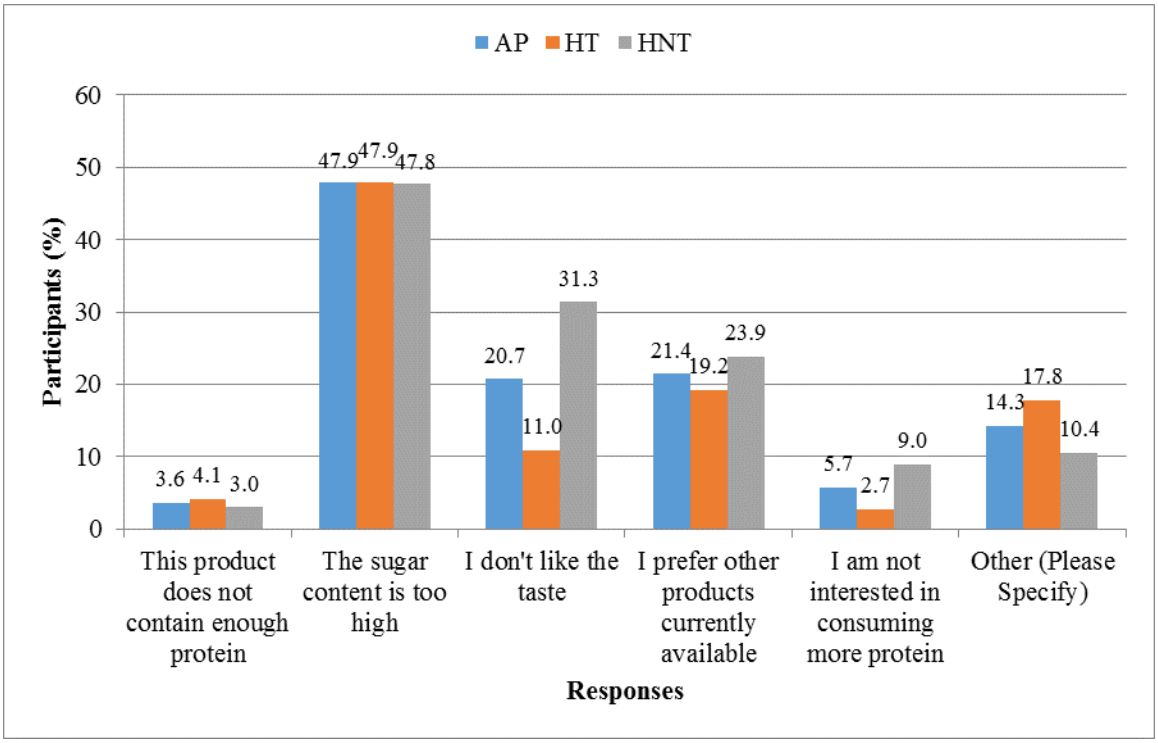


Figure 4-14: Results of asking participants to indicate the concerns they felt applied to this product from a list. The concerns participants selected in the "other" category are shown in Table 4-6. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they had previously tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

Table 4-6: Responses from all participants (AP) who selected "other" as one of their choices when asked to select from a list of potential concerns they might have about the product. If a panelist selected "other," he or she had to enter a comment in order to proceed to the next question in the survey. AP represents a data pool with all participants in the sensory study (n= 140).

Participant Number	Comments
psu107	dont currently buy protein goods.
psu73	After tasting, no concerns
psu36	I am worried about the calories in this product.
psu74	I'm concerned about the potential artificial sweeters used, they weren't explained.
psu125	packaging is messy
psu128	It has some artificial taste
psu51	texture is too slimy
psu83	difficult to eat
psu87	I am not in love with the taste but again, if it had lower sugar, it would be great in a smoothie.
psu31	challenging to eat out of tube.
psu85	texture

psu41	why no fat?
psu22	no concerns
psu59	clories were a bit high
psu19	not really portable to take with me to the gym
psu37	high carbs
psu67	Carb count is a little high if you are watching your carb intake
psu112	no concerns, sample was very good
psu42	the packaging - opening the plastic tube
psu10	no concerns other than maybe smaller tube

Nutritional Information

Participants were asked to complete a just-about-right scale (JAR) and a concern scale to evaluate the level of calories, protein, and added sugar in the product. Panelists were asked for their opinion after they had read a description of the product, but before they had sampled the product.

The majority of participants (70%) felt that the number of calories reported on the label for this product was "just-about-right," as shown in Figure 4-15. For comparison, only 30% of the participants felt that the number of calories was something other than "just-about-right" for the product, with 22.4 of those believing the number of calories was "slightly too many" or "far too many." Figure 4-15 shows the results obtained from the HT subgroup for the number of calories JAR scale. The average for this subgroup is 67.1, showing little difference between the AP group and the HT subgroup. Figure 4-15 shows the combined results from the AP, HT, and HNT groups.

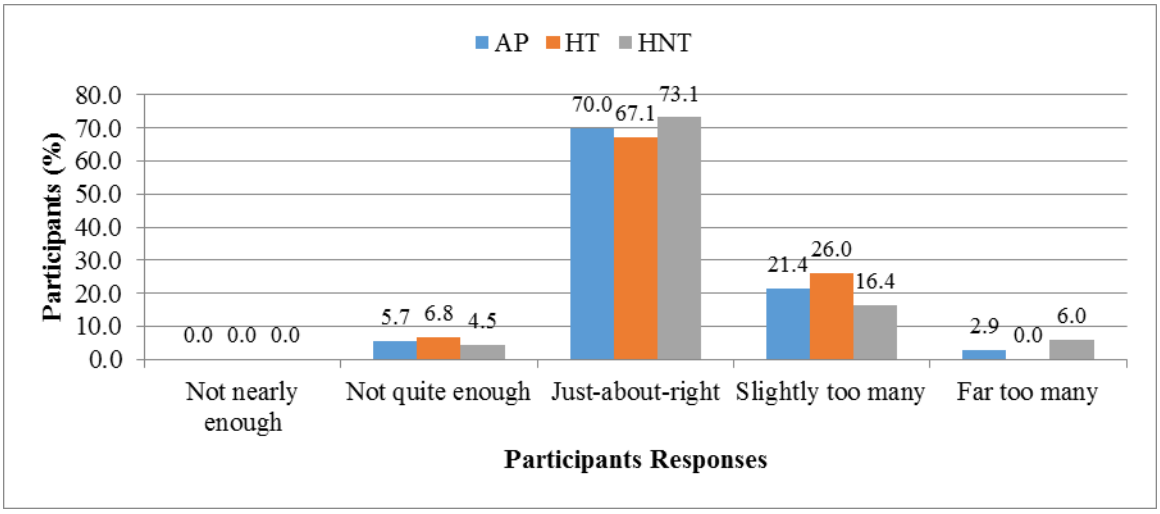


Figure 4-15: Results of the just-about-right scale for the number of calories in the product. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they had previously tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

There also appeared to be little difference between the groups for the concern scale with regard to concern over calories (Figure 4-16). There seemed to be a wide range of variation between participants' concern over the number of calories. About a quarter (22.9%) of the AP group described themselves as "not at all concerned" with the number of calories in this product, while 27.9 percent rated themselves between "neutral" and "extremely concerned." The number of neutral responses was 28.6 percent, indicating that the responses were relatively evenly distributed, with the exception of the "extremely concerned" category which only 5 percent of participants selected. About two-thirds (67.2%) were between "not at all concerned" and "neutral" in concern over the amount of calories in this product.

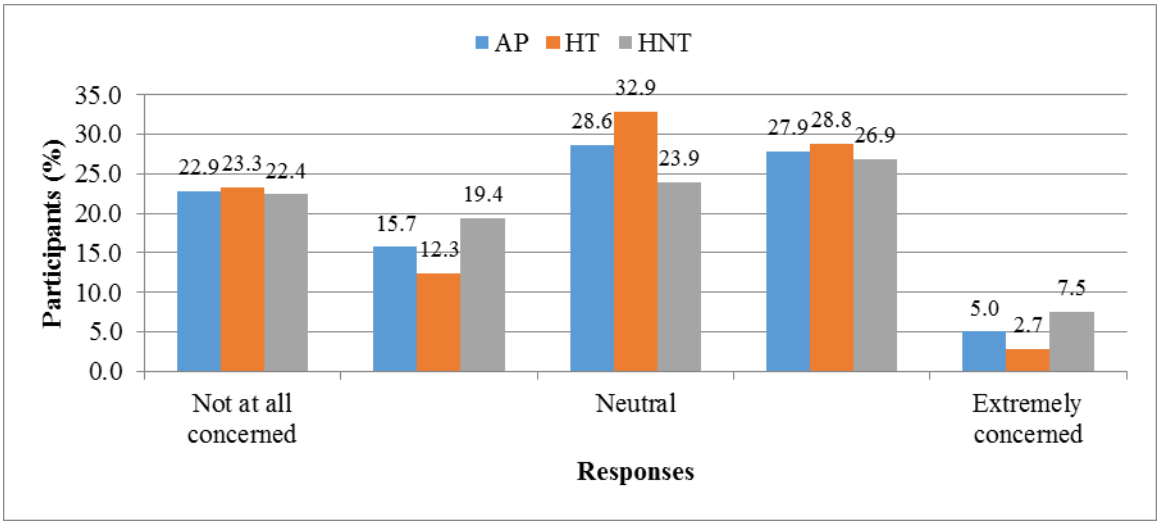


Figure 4-16: Results of a concern scale regarding participants' concern about the level calories in this product. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they had previously tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

There was little variation between the groups analyzed with regard to the protein JAR, as shown in Figure 4-17. An overwhelming majority of participants (87.9%) felt that the amount of protein in the product was "just-about-right." Of all participants in the study, 8.6 percent thought there was "not quite enough" protein in the product, while 2.9 percent believed there was "slightly too much" protein. The concern scale for protein in this product was again relatively evenly distributed between the various responses as shown in Figure 4-18. Although the percentage that were "not at all concerned" and the percentage that were "extremely concerned" remained relatively constant regardless of the participant's background with supplements, a larger percentage of the participants who had previously tried high protein supplements (30.1%) reported that they were somewhat concerned in comparison to the participants that had not (19.4%). Conversely, a larger percentage (32.8%) of participants who had never tried high protein products said they were "neutral" in concern about this product, while only 26% of those who had indicated "neutral" concern.

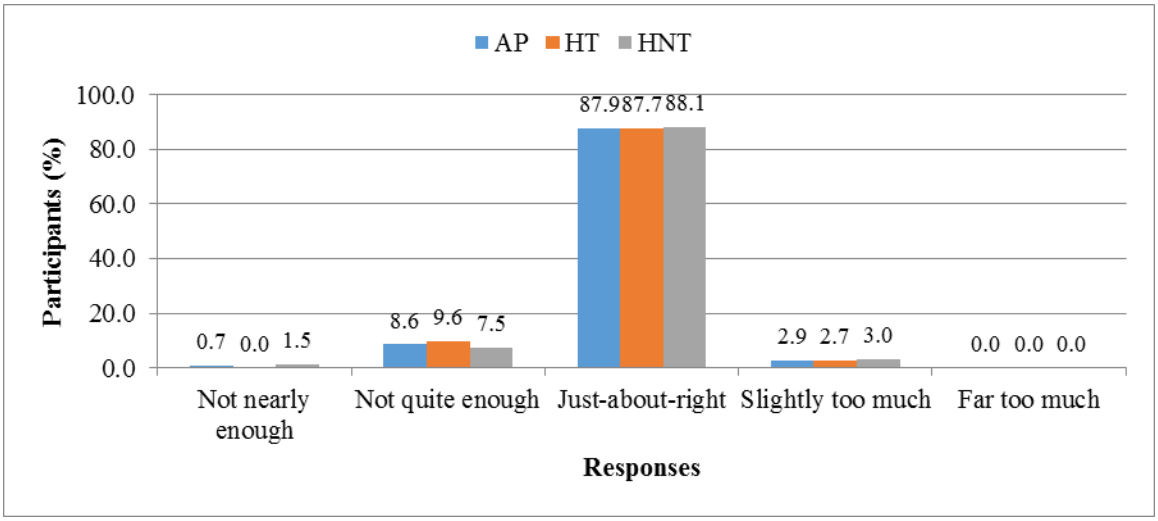


Figure 4-17: Results of asking participants to complete a just-about-right scale for the amount of protein in the product based on reading a sample nutrition label. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they had previously tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

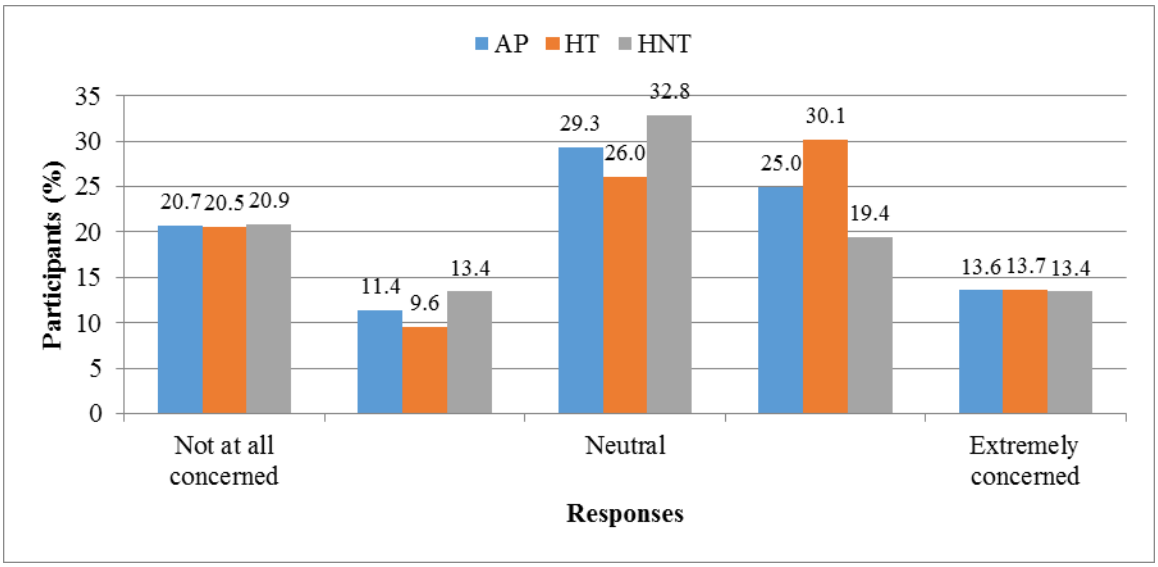


Figure 4-18: Results of asking participants to complete a concern scale for the amount of protein in the product based on reading a sample nutrition label. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they had previously tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

The data from the JAR scale for amount of added sugar (Figure 4-19) indicated that participants thought there was "slightly too much" added sugar with 53.6 percent of all participants responding in this category. 20.7 percent of AP group participants indicated that there was "far too much" added sugar,

while 23.6 percent of AP responded that the amount of added sugar was "just-about-right." Of the HT participants, 31.5 percent felt that the amount of added sugar was "just-about-right," while 23.6 percent of HNT participants indicated that the amount of added sugar was "just-about-right." Looking at the levels of concern for added sugar (Figure 4-20), 44.3 percent of AP indicated that they were between "neutral" and "extremely concerned" about the amount of added sugar in the product. The HT group only had 13.7 percent of participants in the "extremely concerned" category, while the HNT group had 25.4 percent in this category.

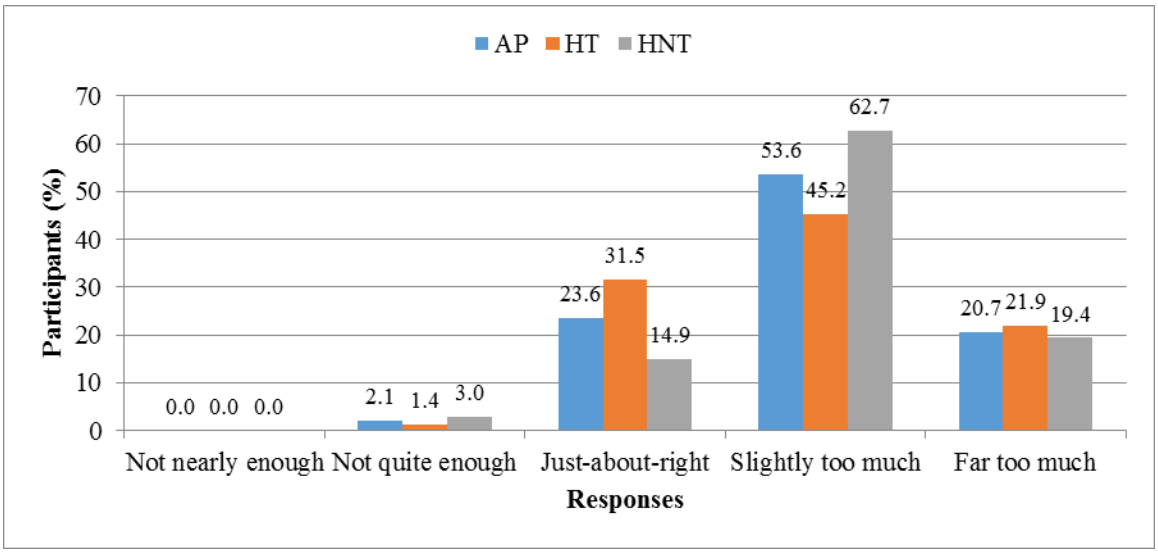


Figure 4-19: Results of a just-about-right scale completed by participants with regard to the amount of added sugar in the product. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they had previously tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

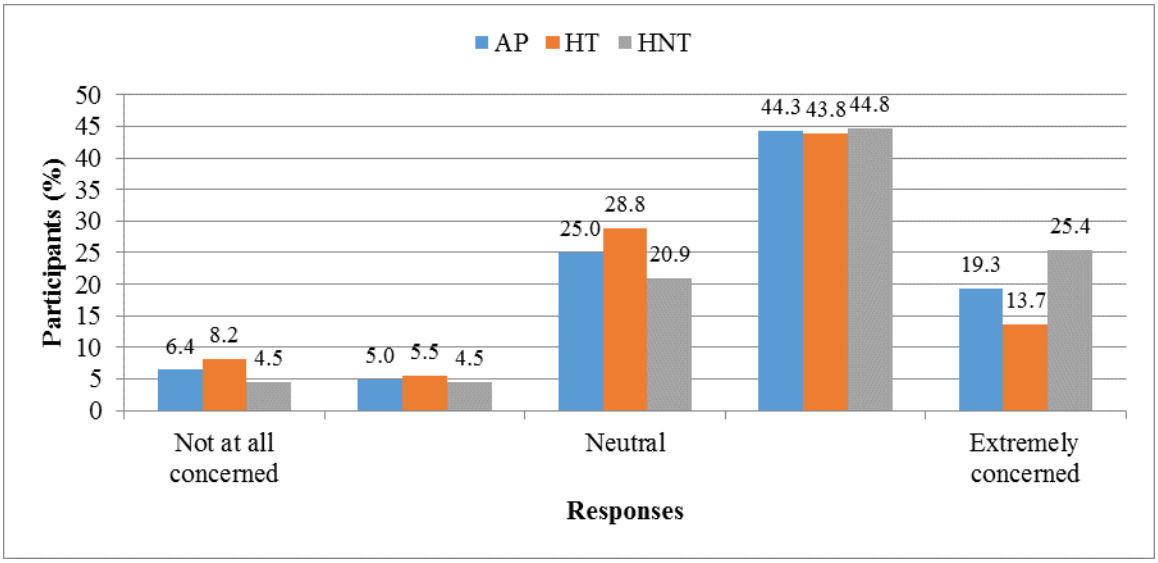


Figure 4-20: Results of a concern scale completed by participants with regard to the amount of added sugar in the product. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they previously have tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

Sweetness

In addition to overall liking, participants were specifically asked about their liking of the sweetness, chocolate flavor liking, and packaging liking. They were asked both how much they liked each aspect as well as to rate the amount of sweetness and chocolate flavor. An open comments section was provided for each of these sections, where participants could respond in an open-ended manner.

The data for sweetness liking, as shown in Figure 4-21, indicated that a majority of participants (73.6%) liked the sweetness of the product to some degree. Of the participants who had previously tried high protein products, 78.1 percent liked the sweetness of the product to some degree. When asked about the level of the sweetness in the product, 63.6% of AP indicated that the amount was "just-about-right." This is shown in Figure 4-22. There was a slight difference between the perception of sweetness between the HT and HNT groups. 65.8 percent of the HT group felt that the sweetness was "just-about-right" while 61.2 percent of the HNT group placed the sweetness level in the same category. More of the HNT group (29.9%) thought the product was "slightly too sweet," while 19.2 percent of the HT group thought

it was too sweet. Only 6 percent of the HT group thought the product was "not quite sweet enough," while 12.3 percent of the HT group thought the product was placed the product in the same category. Comments regarding HT group perception of sweetness can be found in Table 4-7 and in Table 4-8 for HNT group.

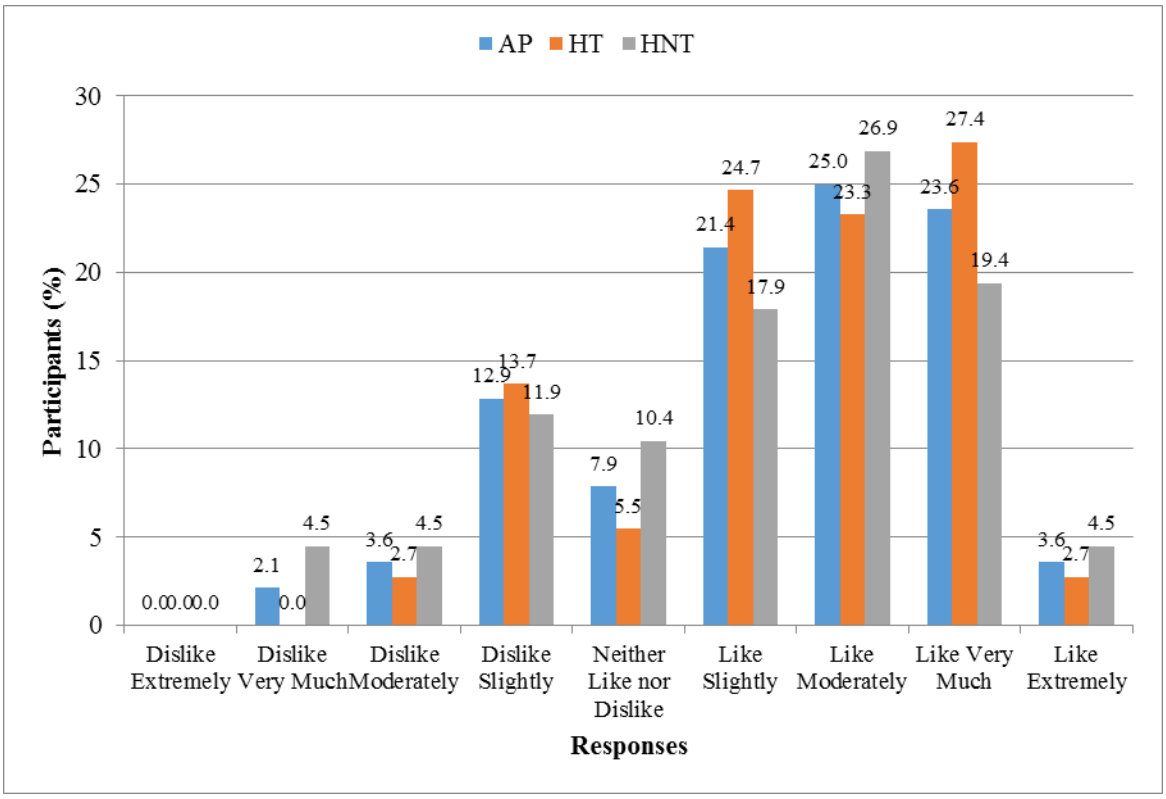


Figure 4-21: Results of a 9-point hedonic scale completed by participants with regard to their liking of the products' sweetness. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they had previously tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

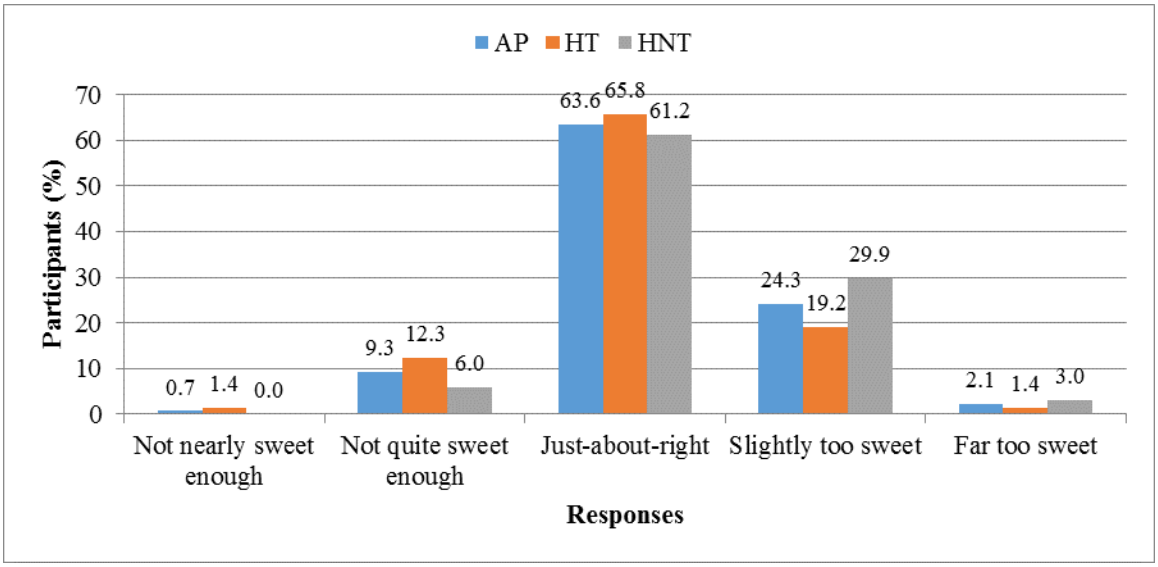


Figure 4-22: Results of a 5-point just-about-right scale completed by participants with regard to the sweetness level in the product. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they had previously tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

Table 4-7: Responses given by participants who have tried high protein supplements (HT) regarding the sweetness of the product. HT is a data set from only those panelists who indicated they previously have tried a high protein product (n=73). Only participants who gave responses are listed in the table. HT is a data set from only those panelists who indicated they previously have tried a high protein product (n=73).

Participant Number	Comment
psu16	no
psu82	Tastes fairly good. Not too overpowering
psu136	no
psu4	tastes like a regular popsicle. very good!
psu107	could be a little sweeter
psu57	The sweetness of the product takes a second to kick in. When it kicks in it is tasteful and last until the end.
psu5	Sweet for a protein product but perfect for a healthy popsicle replacement
psu8	Perfect
psu80	The sweetness and taste of this product reminds me of a tootsie roll. I'm not sure if this is the flavor I want from my protein supplement.
psu129	The sweetness was spot on. It tasted good.
psu72	The balance of he sweetness is pretty good. However I would prefer a less sweet product with a stronger chocolate/cocoa taste. Using more cocoa powder could also be a way to decrease the total amount of sugar and calorie per serving while conserving a good taste and improve the global macros of the product.

Participant Number	Comment
psu12	It's not particularly sweet, but it tastes like fudge, which is impressive. It has the appropriate level of sweetness.
psu137	It is sweet but I don't like it.
psu50	It tastes just like a fudge-cicle
psu62	nope, pretty balanced
psu132	good sweetness, doesn't taste artificial
psu91	sweeter than I thought it would be, but it was a pleasant surprise.
psu85	sort of a chalky taste
psu123	it tastes more sugary than chocolatey
psu59	I like the sweetness, but who wouldn't. The amount of sugar carbs is concerning.
psu139	sweetness is perfect
psu114	the sweetness tastes like an artificial sweetener, not a real sweet flavr.
psu42	it did not seem too sweet, texture was good and flavor was also good.
psu29	surprisingly the taste is pretty good with the flavor of choc
psu20	I would be more likely to consume this product if it were less sweet.
psu61	almost tastes like artificial sweetener
psu89	I would have some concerns about the # of grams of sugar in the product if purchasing, but it does not taste too sweet to me and is very good.
psu104	sweetness is overwhelmed by other problems

Table 4-8: Comments regarding sweetness from participants who previously have not tried high protein supplements (HNT). Only participants who gave responses are listed in the table. HNT represents those participants who reported they have not tried a high protein product (n=67).

Participant Number	Comment
psu6	The product isn't lacking sweetness and also isn't overly sweet.
psu7	Tastes like artificial sweetener. 21 grams of sugar, very high.
psu2	Good fudge flavor.
psu64	I do think it would be more appealing if there was less sugar and if it was a little less sweet.
psu95	it taste pretty good for the first bite, but may feel a little more too sweet if consume the whole serving
psu100	pretty good sweetness.
psu108	Fairly strong sweet aftertaste
psu130	I think the sweetness level is about right, and that it's not the problem with the product.
psu142	I think there can be even less sugar in it.
psu128	Its too sweet
psu51	it might be too sweet for some people, but I liked it
psu87	When I first saw the label, I thought the sugar content seemed high which

Participant Number	Comment
	is always a concern when purchasing protein supplement products. When tasting the product, the taste is less sweet than the powder supplement I am currently using. Personally, I think this frozen bar could have less sugar and be even be less sweet to the taste because I would use it with bananas and berries in a smoothie which would add natural sweetness. With that said, I prefer nutrition over taste.
psu127	Little less would be good
psu86	na
psu65	Too sweet for a protein supplement
psu22	good chocolate flavor
psu121	nice chocolate flavor - good after taste
psu101	the sweetness level is perfect
psu11	to sweet for my taste
psu53	seems about right
psu40	sweetness ok but mouthfill not right

Flavor

The same progression of questions (liking, level, comments) was presented to participants regarding the chocolate flavor of the product. Figure 4-23 shows the results of asking participants liking of the chocolate flavor. Of all participants in the study, 73.6 percent of liked the chocolate taste of the product to some degree. Regardless of history with supplements, participants' liking of the chocolate flavor seemed to follow the same trend. With regard to chocolate level (shown in Figure 4-24), 60 percent of AP group thought the flavor was "just-about-right." 68.5 percent of the participants in the HT group thought the chocolate flavor was "just-about-right," while only 50.7 percent of the participants in the HNT group felt that the level of chocolate was "just-about-right." Of the HT group, 24.7 percent selected "not quite enough chocolate," while 41.8 percent—almost double the percentage—of the HNT group felt that the chocolate level had "not quite enough chocolate." None of the participants felt that the product had "far too much chocolate."

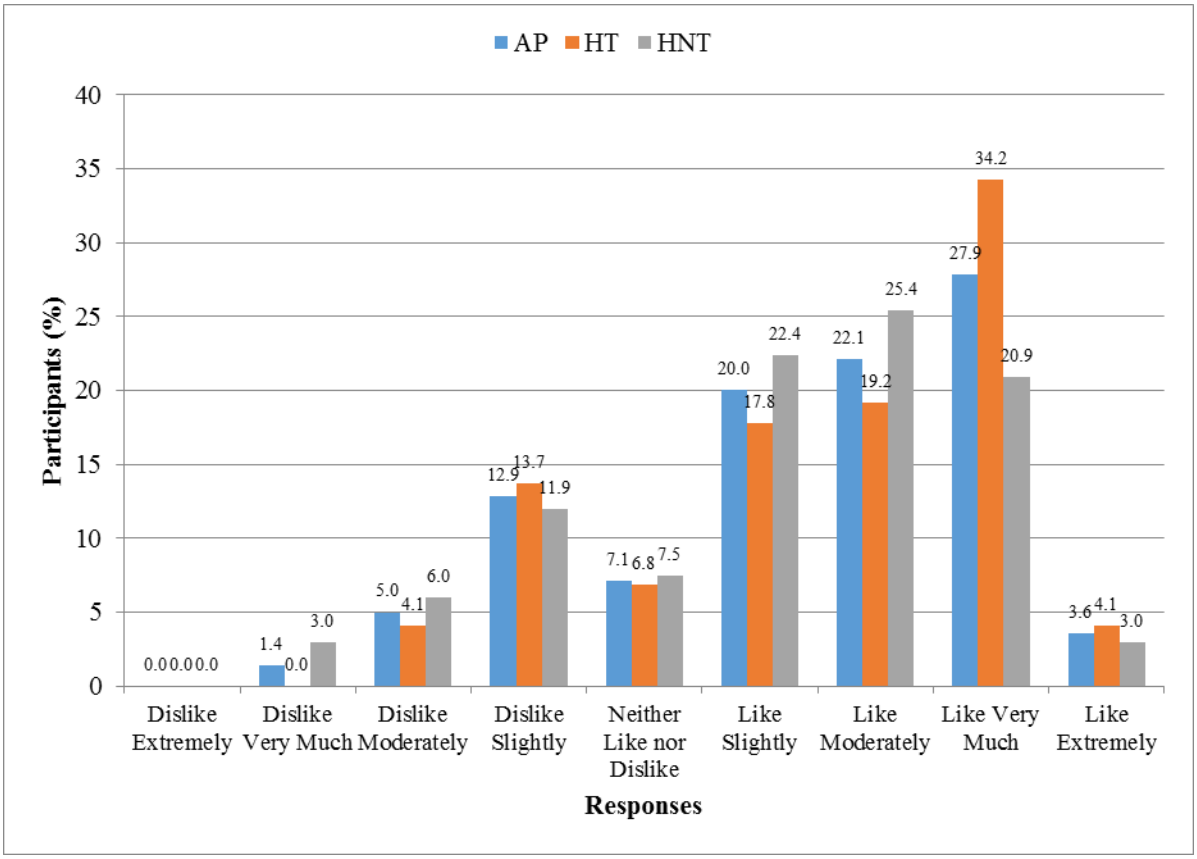


Figure 4-23: Results of a 9-point hedonic scale completed by participants with regard to their liking of the chocolate flavor in the product. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they had previously tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

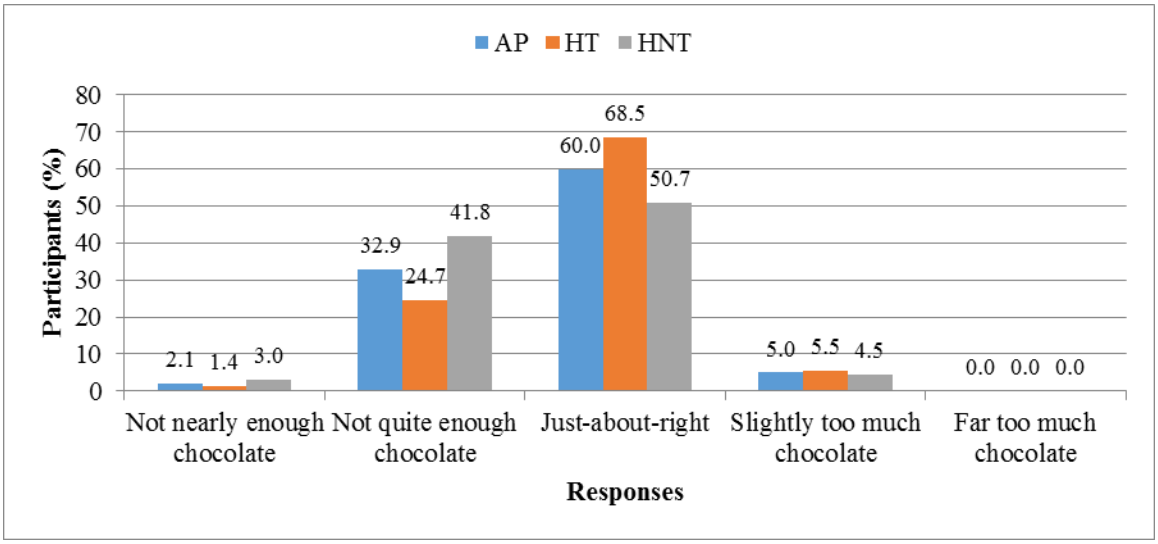


Figure 4-24: Results of a just-about-right scale completed by participants with regard to the level of the product's chocolate flavor. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they had previously tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

Packaging

When asked to rate their liking of the packaging, the distribution of the groups was similar, regardless of the participants' grouping based on their background with supplements. This result is shown in Figure 4-25, indicating that a majority of participants did not like the packaging. Fifty-five percent of participants did not like the packaging to some degree, while 10.9 percent "neither like nor dislike" the packaging. About one third, or 35.1 percent of participants, viewed the packaging favorably. Participants were asked to answer either yes or no to the question, "was the product easy to consume?" Represented in Figure 4-26, this data had almost no variation between groups. Exactly 25 percent of participants answered "no," while 75 percent thought the product was easy to consume. Comments regarding packaging can be found in Table 4-9 for the HNT group and Table 4-10 for the HT group.

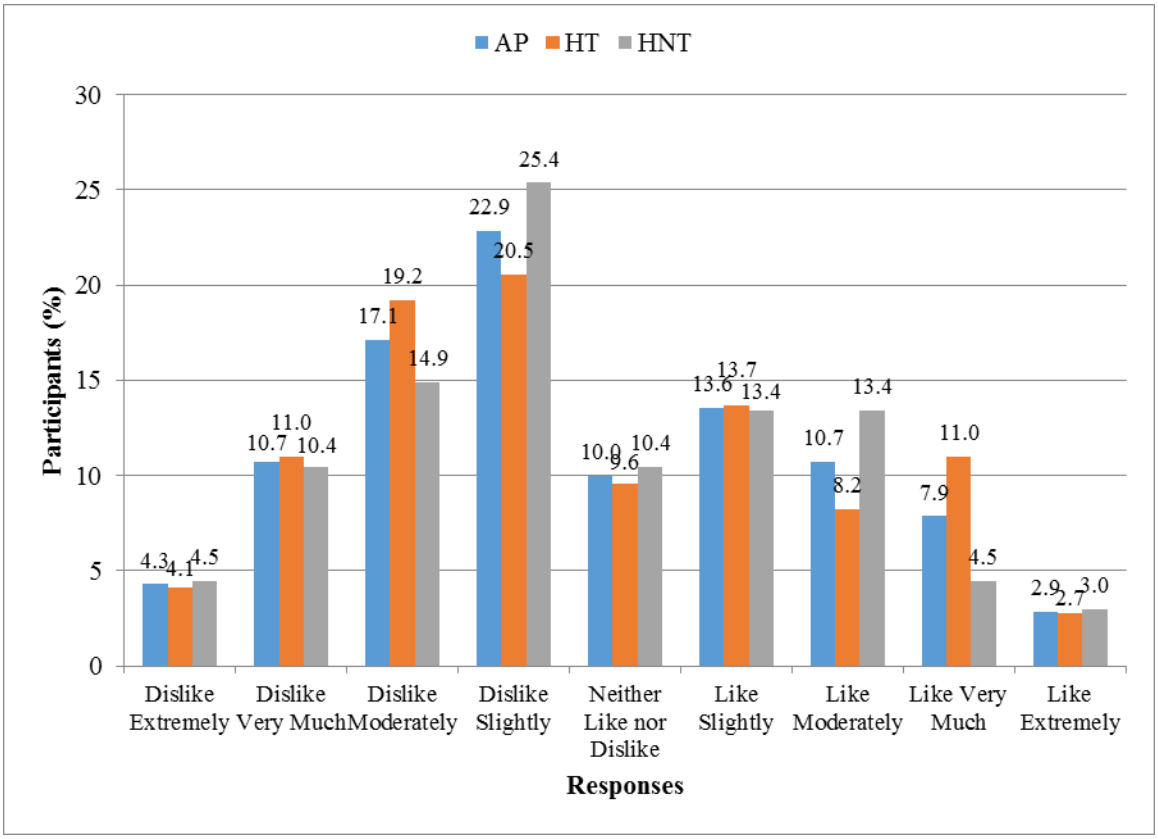


Figure 4-25: Results of a 9-point hedonic scale completed by participants with regard to how much they liked the product's packaging. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated had previously have tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

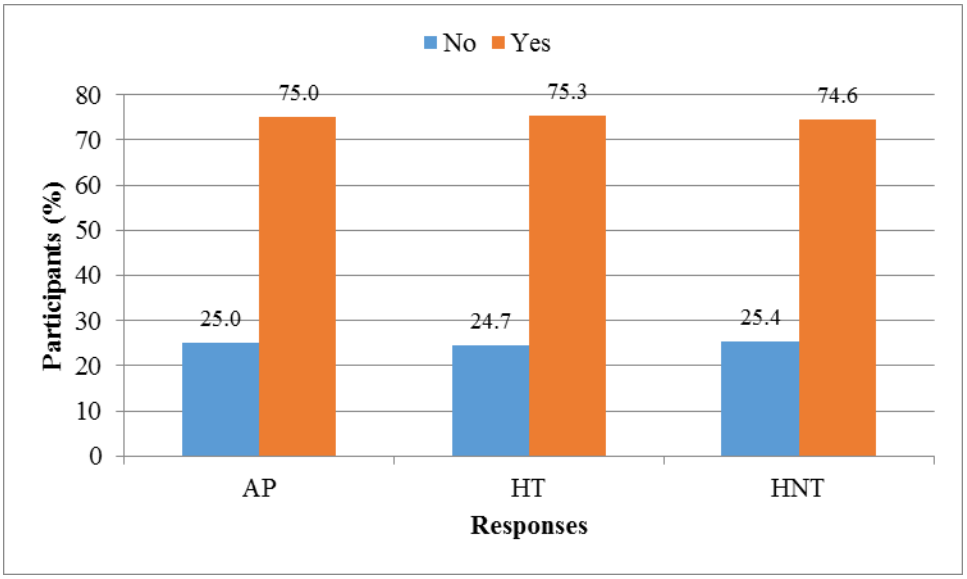


Figure 4-26: Results of a yes-or-no question asking participants if the package was easy to open. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they had previously tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

Table 4-9: Comments regarding the product's packaging from participants who previously have not tried other high protein supplements (HNT). Only participants who gave responses are listed in the table. HNT represents those participants who reported they have not tried a high protein product (n=67).

Participant Number	Comment
psu140	may be easier to eat if it were a popsicle on a stick. Right now it's kind of difficult to squeeze out of the tube
psu35	maybe easier to get out of tube? Since it is frozen it is hard to get it all out
psu6	No
psu7	difficult to access through the packaging.
psu68	It doesn't look very appealing
psu141	The product can be easily consumed, but seems will be harder when you get to the end.
psu2	very easy to eat. not messy which I like. It reminds me of a Go-Gurt
psu58	it was better than I thought it would be
psu64	I did have to work a little to press it out because it was thick but it didn't give me too much trouble! Would a push- up pop idea work?
psu95	it a little bit gross when you need to squeeze the content out, it may be better to put it into a plastic container(like ice cream)
psu92	Could have a design
psu100	it's difficult to get the product out of the packaging and into one's mouth.
psu32	Hard to squeeze out the popsicle
psu108	It is difficult to get the remainder of the product out of the packaging, as it

Participant Number	Comment
	doesn't slide out of the tube easily.
psu130	it's not very appealing...
psu142	If the package can be shorter so that it can be fully filled in a round shape, it could look better.
psu143	The package is not appealing. The shape of it is a little bit weird.
psu21	The packaging needs something more exciting on it, it looks terrible in this weird tube
psu36	It can get a little messy when it starts melting. I would prefer a yogurt-like packaging
psu99	if planning to serve it frozen consider a container that one can scoop the product out instead
psu128	I wasn't sure how to eat Whether to peel it or squeeze it out
psu51	it was harder to eat the contents of the bottom of the tube
psu83	the product was pretty difficult to eat from this packaging. I don't see myself walking out of the gym and trying to eat this thing after a workout. I understand it's supposed to be like a freeze pop, but the product is too thick to move up in the packaging. This would almost be better as a popcicle with a wooden stick, instead of the plastic packaging.
psu84	prefer it to be a stick
psu15	difficult to open
psu87	I really dislike the clear packaging and would hope that if this product went to market, the package would not be clear at all. It is easy to consume straight from the package but I would be hard to put it in a smoothie. (I never considered a frozen protein product, but this would be great to use for smoothies instead of almond milk, protein powder, frozen fruit - I could use the frozen protein, and fresh fruit.)
psu127	None
psu134	I have a little concern of food safety regarding to the packaging. It seems not convenient to consumed after work-out or to carry around.
psu31	I would rather see it on a popsicle stick
psu56	It doesn't slide out like a popsicle. The consistency and the packaging make it a little awkward.
psu86	it was hard to slide out of the packaging
psu126	I might like it to be packaged in a cup and eat with spoon.
psu65	The packaging is practical but not pretty. I would rather eat this as an ice cream with a spoon
psu77	great idea - easy to use and quick
psu13	difficult to remove from packaging
psu48	I think this is good. maybe a tad bit sweeter in flavor but other than that it is good.
psu14	it was a little hard to get out
psu122	packaging was the major issue with this product....was not easy to get out

Participant Number	Comment
	and it sort of made it look like poop for a lack of better wording.....too plain and needs to push out like a push pop....and cover it with a logo of some sort.
psu22	hard to eat, would be better in a package you use a spoon.
psu103	no
psu106	softer plastic tubing
psu121	very easy to eat. You can't make a plastic tube too exciting but it's easier to eat than having it on a stick, etc
psu43	would like better if used a sugar substitute like truvia
psu11	some coloring on wrapper and easier method to push up the snack to eat
psu28	slightly unappetizing packaging but easy to eat
psu25	Its convenient as a consumable product though I prefer a container not an icy pop type plastic push up. Messy and can't get to the full product
psu69	I would prefer a cup with a spoon or a regular popsicle without the plastic
psu105	The packaging is ok - I like minimal packaging to keep costs down.
psu78	did not like the package, too much sugar
psu79	not sure if I would want a frozen product because it my be melted b y the time I consume it
psu111	sorry, but it looks a little like turd, but maybe with labeling, it would look better
psu44	A bit hard to push up to the opening.
psu53	at first it was kind of hard to push it up
psu54	good idea!!!
psu145	It'll be better in a more traditional popsicle form.
psu40	it appears you would need a pair of scissors to open this! not exactly a snack on the run!

Table 4-10: Comments regarding the product's packaging from participants who previously have tried high protein products. Only participants who gave responses are listed in the table. HT is a data set from only those panelists who indicated they previously have tried a high protein product (n=73).

Participant Number	Comment
psu33	no
psu16	The packaging is the worst thing about this product; it makes it difficult to consume and messy
psu75	more design
psu1	Too plain. Looks like astronaut food. Not very apeeling
psu4	love it. like a go-gurt. very nice
psu107	you have to slide up the bottom of ther popsicle. Would be nice if could be pushed up somehow, to make it easier.
psu5	the only hard part was pushing the product through the packaging.

Participant Number	Comment
psu8	no
psu73	Looks like poop
psu80	My initial impression was that it looked like a frozen turd.
psu98	I like the idea of a tube delivery system, but it is difficult to move the frozen product up the tube as I eat it. Frozen popsicles typically slide up the tube as it is consumed, but the product gets stuck and I have to put too much plastic in my mouth. Also, the clear packaging does not make the product look appetizing; consider using an opaque package.
psu133	It looks like a turd
psu24	smaller package would be better
psu94	I would like smaller pack, since the bottom is hard to reach.
psu109	Easy to consume and not messy.
psu72	At first it was a little hard to get the product out of the tubing. Once it melted a little after a minute from holding it was wasn't too bad. But it's appearance is awful. Honestly, it looked like frozen dog poop at first.
psu12	I would go with small individual cup containing 25g of protein per cup.
psu74	The packaging makes the product look very unappetizing. I was also not immediately sure how to eat the product. I opaque packaging that tore easily might be better.
psu137	packaging is fine. Product is a little bit soft.
psu138	Usually the people that drink protein milkshake do it during their gym routine... They have a special container where put the powder and mix it (that is not my case), and I am not sure if a cold dessert could be a good idea for that people.
psu50	a container would be easier to eat
psu60	It made the product look cheap. If I had to make a decision based upon packaging alone I would not purchase this product. Perhaps it would work better in a shorter and wider package that was not clear.
psu62	the tube is slightly too wide
psu63	No, the packaging was appropriate for the product it contained.
psu66	Package does not look appealing. It was hard to eat after the first few bites.
psu120	The tube is cold for holding too long.
psu38	Not sure about concept. I would like to take it with my gym and this might melt on the way.
psu93	Not very attractive, it looked like a poop log but if it's more environmentally friendly to have less wrapping I'm all for it. If there is an alternative material to plastic, even better.
psu113	The packaging makes the product rather unattractive to consume.
psu132	it can be more fancy-looking
psu91	I said it was easy but it wasn't as easy as it could be. the thickness of the product makes it a slight challenge to get to the bottom parts of it.
psu97	Very convenient packaging and easy to use, too bad it makes it look like a turd. Can't be helped, I suppose. Thumbs up.

Participant Number	Comment
psu30	Product was hard to push out of the packaging
psu119	great idea didn't know something like this even existed
psu41	It was easy to consume after it melted a little. When I first received it, it was hard to get out initially.
psu117	it was difficult to squeeze the product up to the top
psu59	the packaging was bland and made it look distasteful. it looked like space food or something children would be fed at a school cafeteria.
psu76	had to wait for it to soften to move it easily in the sleeve.
psu118	the packaging make it tought o eat
psu19	once it thawed a bit it was easy
psu37	it is convenient
psu114	it is fine.
psu49	should be easier to push the product up from the bottom/
psu67	Hard to move the contents up if it is too frozen. Needed to wait for it to thaw a little to be able to move up
psu90	It was hard to get out of the packaging. Packed a little too tight
psu42	I would be concerned with how to open it easily - I would rather have this on a stick
psu18	the packet could be more inviting.....
psu34	wider and shorter might make it easier to push put
psu55	Extremely difficult to get entire product out of tube to consumer. Frozen product did not easily slide up tube. However, once I was able to get to the product, I enjoyed it.
psu29	very convenient
psu88	having it like a freeze pop is a great way to eat it
psu10	it was hard to push the popsicle up in the tube. Once I got it started it was better but lost some of the product in the bottom of the tube.
psu61	Easy to use, and access the contents. I like that.
psu89	I like that it is firm and you are able to bite down on the packaging to remove some of the product
psu104	Once I got the package open, it was easy to slide the product to the top, but It was hard initially to open the package
psu144	very unappealing, looked like dog....
psu135	I am assuming that there will be some graphics on the package that is likely to cover the product. Because there is no package design, one can see the entire tube which appears mottled - some areas darker or lighter than others. This suggests that the product is not mixed enough. It is not attractive. after I eat the first bite, what do I do with the remaining plastic?

Price and distribution

Participants were given a list of price ranges and asked to select the range that contained the highest price they would be willing to pay for a packaging containing six protein popsicles, as shown in Figure 4-27. The mode of this data was "$4.00- $5.99," which 27.9 percent of all participants felt was the most they would be willing to pay. Of all participants participating in the study, 16.4 percent indicated they "would not buy this product regardless of price." Of the HT group, only 4.1 percent of participants said they wouldn't buy the product, while 16.4 percent of the participants in the HNT group were not willing to buy the product at any price.

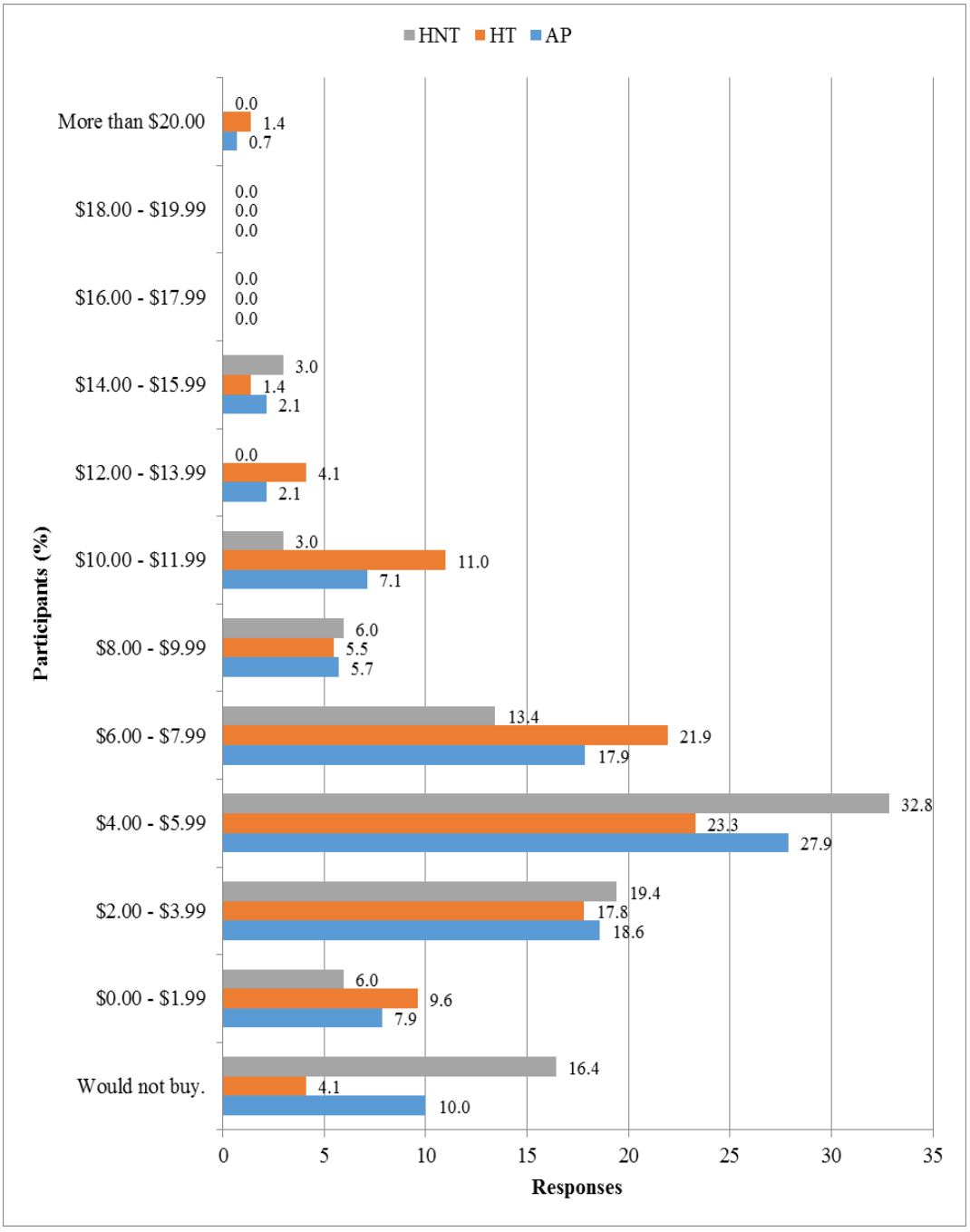


Figure 4-27: Shown are the results of a question which asked participants to select the price range that contained the highest amount they would be willing to pack for a package containing four protein popsicles. The "Would not buy" category was chosen by participants who "would not buy this product regardless of price." AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they had previously tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

When asked about buying the packages individually or in a package and pre-frozen or unfrozen, participants overwhelmingly preferred buying the popsicles in a bulk package, as shown in Figure 4-28. Participants could only select one option. About three-quarters (71.5%) of all participants indicated that they would prefer to buy the product in bulk. More than a third (38.6%) of all participants preferred "to buy a pre-frozen package containing multiple tubes." About a third (32.9%) of all participants indicated they would prefer "to buy a non-frozen package containing multiple tubes." Few participants (5.7%) indicated that they would "prefer to buy a non-frozen individual tube of this product," while 12.1 percent indicated that they would prefer to "buy a pre-frozen, individual tube of this product." The largest difference between the groups occurred in the "I would not buy this product under any circumstances category," where 5.5 percent of HT group and 16.4 percent of HNT group were not interested in buying the product at all.

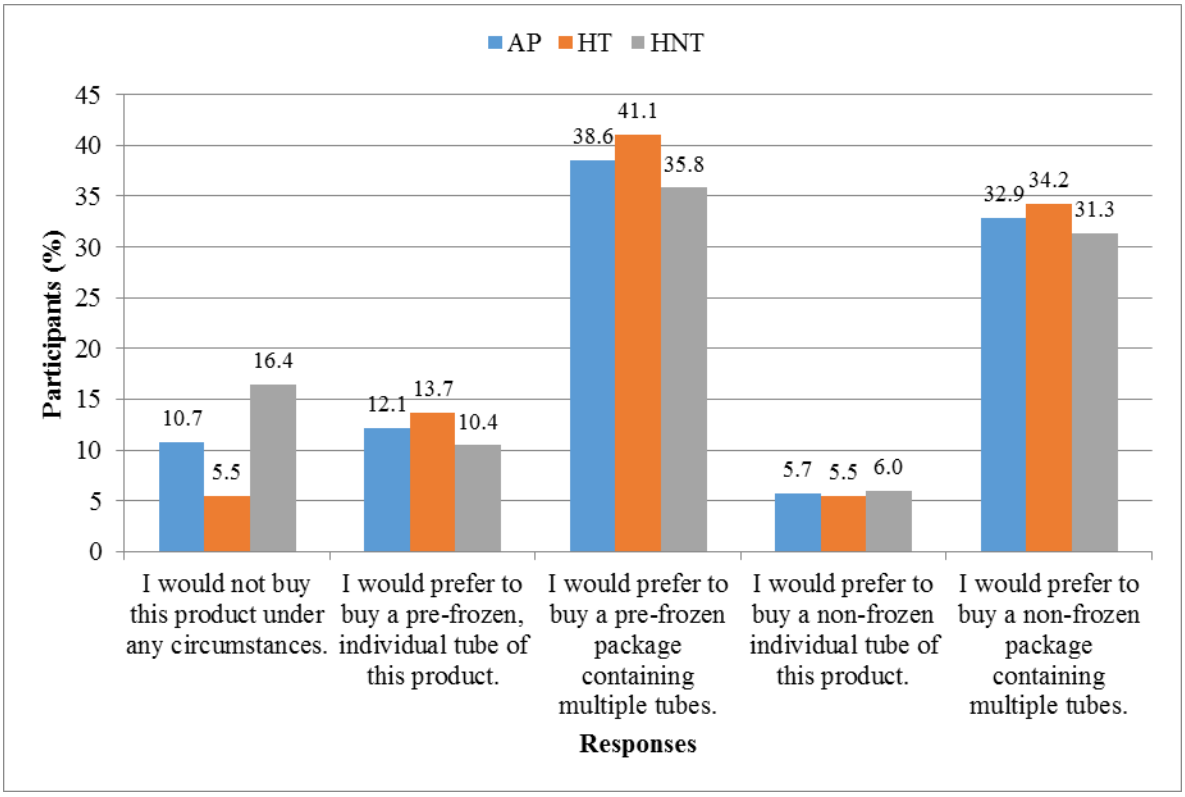


Figure 4-28: Shown are the results of a question which asked participants to select which of the scenarios shown on the x-axis they would most prefer as an option for buying this product. AP represents a data pool with all participants in the sensory study (n= 140). HT is a data set from only those panelists who indicated they had previously tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

Chapter 5

Discussion

Formula and Production Process

The heat treatment used on this product was designed to be particularly aggressive because one of the initial goals was to attempt to make the product shelf-stable. In order to accomplish this, the product would need to be retorted in order to achieve commercial sterilization. It was determined that testing this was beyond the scope of this study due to time constraints and the relatively low melting point of low density polyethylene (the material used to make the tube), which would not withstand retort temperatures. A large concern with the initial formulation was whether or not the product would form a gel at sterilization temperatures. This is discussed further in the chapter on recommendations for future research.

In order to produce the number of units required for the final version, it was necessary to alter the way that the product was produced. This created unique challenges that had not been encountered when producing at a lower level, ranging from relatively simple to more complex. Finding larger scales to weigh ingredients was a relatively simple problem to overcome, however, a harder challenge was the problem of protein hydration. When producing a 500g batch, short bursts of mixing combined with waiting were determined to be sufficient for the protein to hydrate and for a relatively homogenous dispersion to take place. When the larger mixture was made for the sensory study, the wet ingredients were added to the dry ingredients as they had been during the initial process, however, it was observed that they formed clumps that

were not hydrating at the same rate as was occurring during the small run. Therefore it was found necessary to use a strainer and a large spoon to manually squish the protein through the strainer. This time-intensive process was extremely successful at breaking up the clumps of protein so that they could be hydrated and a homogeneous mixture could be created.

Ultimately, 163 protein popsicles were produced after the batch was calculated for 175, resulting in a 93.1 percent yield. This was on track with what was expected, given that some of the mix was spilled during the filling process, and some remained on the equipment used in the manufacture process.

Compositional Analysis

It was noted during compositional analysis that the samples did not seem to be completely homogenous in the tubes. This could have affected the compositional analysis, however it seems unlikely since the samples were relatively close in their experimentally determined values. The experimentally determined fat content was higher than the calculated fat content by an appreciable amount (1.038%). Considering the ingredients in the product, it likely that this was due to the whey protein. Since the values for this were typed into the TechWizard program from the nutrition label on the protein's package, it is possible that some rounding took place. Considering that this would get rounded to 1 gram of fat on a label, as opposed to the 0 g which panelists were presented with, it is unlikely that this would have greatly affected panelists' perception of the product.

Sensory Evaluation Study

Introduction

It was decided that just one tube would be tested in the sensory study for several reasons. The sensory study was already relatively long, and adding more samples and questions might have fatigued participants. Additionally, it was determined that the main goal with the sensory study was to get feedback on the product concept and to gauge the level of interest in the product. This goal would best be served by asking a wide variety of questions about a single product rather than by asking panelists to compare different product versions. It was determined that the chocolate flavor would be used because the flavor was preferred in several casual taste-tests before the sensory evaluation, and the bitterness of the cocoa powder helped to cut the sweetness that was seen in the vanilla flavor.

General Discussion

It is possible the results of the sensory study were affected by the fact that the product melts over time. Participants may have liked the product more or less based on the degree of melting that occurred before consumption. The amount of time a participant took to consume the product therefore could have influence their liking or ease of consumption. Participants were presented with the popsicles as soon as possible after taking them out of the freezer cabinet to minimize variation. Some participants may have warmed the popsicles with their hands, however, which would cause them to be more or less able to slide through the tubing. Prior to being presented to participants, one side of the popsicle was cut. In at least one case, it was

observed that a participant had presumably gnawed a hole in the opposite side of the popsicle in order to open it. After this, workers in the sensory lab were instructed to make sure that the cut side was facing the participant, and this problem was not noticed again. This incident did underscore the potential challenges in terms of perception when sensory testing a new product. Since people do not have preconceived perceptions of how this product will fit into their lives, as they would for a ravioli taste test or even a traditional protein bar, it might take some education to show consumers how they can use this product. For example, psu87 wrote that with the current packaging, it "would be hard to put it in a smoothie."

Although splitting the larger data pool into the two subgroups helped with analysis, and there were several significant differences between the two sets of data (mentioned in the discussion section), it should also be noted that while 52.1 percent of participants reported they "have tried some kind of protein supplement at least once," a higher percentage (56.4%) reported that they "have tried commercially prepared protein "shakes" at least once, and 75 percent reported that they "have tried high-protein nutrition bars at least once." This is shown in Figure 4-6. Therefore, it seems that some of the participants in this survey have varying definitions of what constitutes a protein supplement as opposed to a high protein food. This probably could have been avoided to some degree by including an operational definition of what constitutes a "high protein supplement" in the context of this survey.

Some of the participants made suggestions that would be difficult to act on with an understanding of the scientific principles underlying the popsicle. For example, psu92 commented "If it had a little less sugar, it would be better. The flavor and texture are really good ! [sic]." In this case, simply decreasing the sugar content without making any other changes

would have a very large impact on the texture of the product. Additionally, whatever was added instead of the sugar might also cause concern amongst consumers.

Demographical

Since this product is expected to be more successful in a male demographic, it is important to note the fact that the sensory study was made up of 40 percent male and 60 percent female participants. Indeed, this was demonstrated when the participants were put into two subgroups based on whether or not they had previously tried protein supplements. In the group made up of people that have tried supplements (HT group), the ratio went from 40:60 to almost 50:50, as shown in Figure 4-3. There was a much lower number of male participants in the group made up of participants who have not tried (HNT group) protein supplements. This confirms the assumption that males are more likely to have tried protein supplements, and was confirmed to be statistically significant through analysis with a t-test, as shown in Table 5-1.

The average age of participants in this study was 36, and no statistical difference was observed between the average age of the HT group and the HNT group (Table 5-1). Additionally, a one-way ANOVA was conducted on four sections of the overall data: HT, HNT, participants over 30, and participants under 30. The results of this can be seen in Table 5-2.

Table 5-1: Summary table for t-test comparisons between HT and HNT groups performed using Minitab 17 software. A,B Means in the same row followed by a different letter are significantly different at a level of at least p< 0.05). Information summarized in this table is contained in Appendix B.

Question/ Attribute	Subgroup	
	HT	HNT
	Mean (SD)	
Overall Liking	6.70 (1.69) [B]	5.91 (1.80) [A]

Chocolate flavor	6.53 (1.63) [A]	6.15 (1.72) [A]
Sweetness	6.45 (1.5) [A]	6.13 (1.78) [A]
Packaging Liking	4.66 (2.11) [A]	4.61 (1.99) [A]
Number of Calories	3.19 (0.54)[A]	3.24 (0.63)[A]
Concern Number of Calories	2.75 (1.19) [A]	2.78 (1.28) [A]
Age of Participants	36.1 (13.1) [A]	36.4 (13.0) [A]
Gender of Participants	1.52 (0.503) [A]	1.68 (0.46) [B]

Table 5-2: Results of ANOVA analysis on various attributes. A,B Means in the same column followed by a different letter are significantly different at a level of at least p< 0.05). Information summarized in this table is contained in Appendix B.

	Attribute			
Subgroup	**Likely Hood of Purchase**	**Comparison to Other products**	**Subgroup**	**Liking by Experience and Age**
	Mean (SD)			Mean (SD)
HNT-Pre	3.51 (0.80)[B]	3.56 (0.95)[AB]	HT	6.70 (1.70)[A]
HNT-Post	2.88 (1.19)[A]	3.08 (1.03)[A]	Over 30	6.46 (1.74)[AB]
HT-Pre	3.60 (0.72)[B]	3.30 (0.79)[AB]	Under 30	6.13 (1.83)[AB]
HT-post	3.34 (1.04)[B]	3.55 (0.90)[B]	HNT	5.91 (1.80) [B]

Purchase Intent Comparison

It was interesting to see the comparison to other products data from participants who reportedly had never tried another high-protein supplement. Based on reading the description, 43.3 percent thought that it was about the same as other high-protein supplements, and only 14.9 percent thought it was worse than other high protein products. After trying the product, however, the number of participants in the HT group who thought it was worse than other products jumped to 32.9 percent, as shown in Figure 4-11. This seems to indicate that these participants, who had not previously tried any kind of protein supplement, did not have any kind of perception of the sensory characteristics that having a lot of whey protein can impose on a

product. This means they were probably picturing a typical sugar and water freezer popsicle instead of the popsicle they received. These results are not discouraging because this group of participants is unlikely to be the target demographic for this product.

This observation illustrates why separating the data based on participants' history with supplements was an effective analytical technique. For the participants who did have experience with high protein products, their comparison of this product to other products increased after trying the product. According to the results, 1.4 percent thought it was "much worse than other high protein products" and 12.3 percent thought it was "slightly worse than other high protein products," both after reading the product description and sampling the product. The only difference that occurred in the HT group between reading the description and trying the product was a greater percentage of them believed the product was better than other high protein products than viewed it as "about the same as other high protein products." This supports the conclusion that participants in the HNT group did not know what to expect when they tried a high protein popsicle. Participants who were not interested in the concept from the beginning remained uninterested, while those who though it was "about the same as other high protein products" only improved their perception of the product after trying it.

Since purchase intent and comparison questions were asked after participants had read a product description and seen a nutrition facts panel, the first time these question were asked approximates a store setting in which a consumer would be looking at a package to evaluate their purchasing decision. Therefore, the results here give an idea of how many people might buy this product from looking at it in a store. The results the second time the question was asked (after participants had sampled the product) may show the likelihood that consumers would re-purchase the product after having tried it.

A one-way analysis of variance (ANOVA) was conducted on the pre and post data from the HT and HNT groups for their likelihood of purchase, yielding four separate groups of data, as shown in Table 5-2. In order to perform statistical analysis on categorical data, numbers were assigned to the different categories. For example, "definitely would not purchase," was assigned a value of 1 and "probably would not purchase" was assigned a value of 2. When analyzed, the HT-pre, HNT-Pre, and HT-Post were found to be in the same group, as shown in Table 5-2, however the HNT-Post was significantly lower. The average of the HNT-post group was 2.88, which is between "probably would not purchase" which was assigned a value of 2, and "might or might not purchase" which was assigned a value of 3. A chart showing the confidence intervals can be found in Table 5-2.

A similar statistical analysis was conducted on the pre and post data from the HT and HNT groups regarding the comparison to other products, as shown in Table 5-2. Again, numbers were assigned to the categorical data, with 1 corresponding to "much worse than other high protein products," while 5 corresponded to "much better than other high protein products." Based on the results of the Tukey's groups, which were shown in Table 5-2. There were three groupings of the data. The HT-post had the highest mean in group A, indicating that participants in this group A thought this product rated the highest in comparison to other high protein products. This is very encouraging, since participants in this group have previously tried a high protein supplement, which means that they are in the best suited to make this determination, and are also the most likely to actually buy this product. While participants in this group did not increase their purchase intent enough to be considered statistically significant, a statistically significant difference was observed between the HT-post group and the HNT-post group, which rated this product the lowest in comparison to other high protein products out of any of the

groups. Again, the information of participants who have actually tried other protein supplements is probably a better indicator of where this product falls in comparison to other products.

The decrease in the likelihood of purchase for the HNT group was probably due to the fact that they did not have a perception of other high protein products on the market. They might have rated this product higher had they been presented with several currently existing products and then been asked to compare this product to them. Ultimately, however, the opinion of participants who have not previously tried high protein products is somewhat irrelevant since they would be outside the demographic for this product.

Also, it is important to note that not all products are going to appeal to every consumer, as tastes and preferences are relative. Therefore, although only 7.9 percent of AP group said they "definitely would purchase this product" (Table 5-2), this could be a successful product if that percentage of the general public "would definitely purchase this product" as well.

Overall Liking

Seeing the percentages of participants who liked the product was overall very encouraging. Regardless of background with supplements, the majority of participants liked the product. The response was extremely positive, with 75 percent of participants indicating that they liked the product to some degree (Table 5-1). People's opinions seem to be somewhat polarized about the product as only 2.1 percent of all participants were neutral in their opinion about the product, with more than fifty percent of the participants liking the product "moderately" or "very much." Based on the results of a t-test performed using MiniTab (shown in Table 5-1), the p-value was found to be 0.009. This means that it is possible to reject the null

hypothesis and conclude that there is a statistically significant difference in degree of liking of the protein popsicle between the HT group and the HNT group.

This difference is probably explained by the fact that the HT group has had more experience with high protein products, much in the same way that an experienced beer drinker will have a different perception of the taste of a beer than will someone who is having their first sip. With the overall liking amongst participants who have experience with high protein supplements being 6.7 out of 9, this shows that participants generally liked the product since an average liking of 5 would have been neutral.

Nutritional Information

The questions regarding this product's nutrient content were presented before participants had the opportunity to sample the product. This was done so that the participants' liking of the product would not bias their responses regarding the nutritional information. Asking questions about the nutritional information along with a product description is also a better way to simulate the conditions under which consumers would be considering buying the product in a store.

When looking at the questions that asked participants "how concerned" they were with the amount of protein or sugar in the product, it is possible that they might have interpreted the question in several different ways. It was intended to ask how much they cared about the amount of sugar or protein in the product, however they might have interpreted it to mean how upset were they by the amount of the ingredient in the product. This could explain why the results for the protein scale were relatively evenly dispersed through "not at all concerned" to "extremely concerned." It could also have been that many participants did not care about consuming more

protein. This seems unlikely, however, since the results were relatively even regardless of background with supplement consumption. Additionally, there are numerous dietary reasons why participants might not want to consume added sugar.

When body-building or attempting to gain muscle mass, athletes are often told to consume more calories in order to support muscle growth. Therefore, many people who are attempting to gain muscle may be ambivalent or prefer a product to have a higher caloric density so that they can increase their caloric intake. At the other end of the spectrum, many people attempt to consume as few calories as possible in order to maintain or lose weight. Due to the varying views on caloric consumption, it would be assumed that there would be varied responses regarding the calories in the product.

As it turned out, it was not possible to conclude that there was a statistically significant difference between either the just-about-right scale for the number of calories or the level of concern over the number of calories between the HT and the HNT groups (as shown in Table 5-1). As mentioned above, this can probably be attributed to the fact that different fitness goals necessitate different approaches to caloric intake. Since the majority (70%) of AP indicated that the number of calories was "just-about-right," the 190 calories which were shown to participants is probably a good number to aim for in the final product.

Sweetness

The participants rated the sweetness of the product highly. There did not seem to be much of a difference between the HT and the HNT groups when examining Figure 4-21, and this was confirmed with a t-test, which had a p-value of 0.258, as shown in Table 5-1. Looking at the

just about right scale for the sweetness, the largest category selected by far was "just-about-right," however 24.3 percent of all participants taking the sensory test thought that the product was "slightly too sweet." Therefore, it might be possible to lower the sweetness of the product slightly so that even more participants find it to be "just-about-right." Since 32.9 percent of all participants thought that the chocolate level was "not quite enough," it might be possible to add a little bit more cocoa powder into the recipe so that the bitterness counteracts some of the perceived sweetness. Thus, this single modification might be able to improve liking of the product. Adding more cocoa powder is unlikely to have as perceivable an effect on the texture of the product as decreasing the sugar content, however a large percentage of the participants wanted to see the amount of added sugar in the product decreased.

Flavor

Whether participants had previously tried supplements did not seem to affect participant's perception of the chocolate flavor of the product. Since most participants have probably tried a range of chocolate flavored dairy products, this was likely an aspect of the product that participants have had experience with, regardless of their previous protein product consumption. No significant difference was observed in liking of chocolate flavor between the HT and HNT groups, as shown in Table 5-1.

Looking at participants' JAR scale responses to the level of chocolate flavor in the product, it appears that the level of chocolate flavor could be increased slightly to increase the number of participants who feel that the level is "just-about-right." Increasing the amount of

cocoa powder in the product's recipe could decrease the amount of sweetness perceived in the product as well (see discussion on sweetness).

Packaging

The packaging was one area of the product that was poorly received by participants. Since this packaging is only a prototype, and would ideally be changed for a more easily opened, and printable package before being sold, it is important to distinguish whether panelists were responding to disliking the tube packaging as a concept or disliking specific aspects about this version of the tube. Although 34.6 percent of participants who like the packaging to some degree (Figure 4-25), the majority of the participants did not like the packaging. It is difficult to tell exactly what aspect of the packaging they did not like, since it is not possible to do a simple question asking about the level of the packaging as it was with sugar or chocolate flavor. In an attempt to address the potential reasons for disliking of the packaging, should they have arisen, a question was asked of participants asking if the product was easy to consume. For all participants, this was split with exactly 25 percent of participants saying "no" and 75 percent responding "yes." There was no significant difference between the HT and HNT groups with respect to the product's packaging Table 5-1. This means that although some of the participants reported it was difficult to consume, this result only partially explains the large number of panelists who disliked it to some degree.

The packaging section received the most number of comments of any of the comment sections, suggesting that panelists felt the most strongly about it. Many of the comments were contradictory, making it difficult but not impossible to parse out trends from them. For example,

panelist psu2 wrote, “very easy to eat. not messy which I like. It reminds me of a Go-Gurt,” while psu36 wrote, “It can get a little messy when it starts melting. I would prefer a yogurt-like packaging.” Panelists’ comments are listed in Table 4-9 which shows the HNT group and in Table 4-10 which shows the HT group. Although many of the panelists’ comments were contradictory, it was possible to notice trends among their comments. A large percentage of the both groups comments regarding the ease of consuming the product, which are exemplified by psu100’s comment “it’s difficult to get the product out of the packaging and into one’s mouth” and psu51’s remark, “it was harder to eat the contents of the bottom of the tube.” Although a number also focused more on the lack of packaging design. Such comments are typified by psu87 who wrote, “I really dislike the clear packaging and would hope that if this product went to market, the package would not be clear at all.” Comments also suggested serving it more as a conventional ice cream product. Psu65 wrote, “I might like it to be packaged in a cup and eat with spoon,” while psu65 wrote, “I would rather eat this as an ice cream with a spoon.” There were also some panelists, such as psu31, who “would rather see it on a popsicle stick.”

A large number of participants did not seem to like the product based on its appearance. Numerous commenters made remarks similar to psu73, who wrote that the product “looks like poop” or psu133, who thought “it looks like a turd.” This is due to the product being wrapped in clear LDPE, which allowed the product to show through the package in combination with the chocolate giving the product a brown color. Were the final product to be packaged in a tube, it would need to be opaque and preferably able to be printed on. This negative image might have influenced participants’ perceptions regarding the packaging. Using vanilla might have negated some of this negative image association.

Price and Distribution

Since the cost of ingredients in a typical freezer pop are very low, it is important to make sure that consumers would be willing to pay a premium to have a high-protein version. Adding 20 grams of whey protein per popsicle increases the cost significantly above the average cost of a freezer popsicle. This increase in costs is typical with high-protein products, so it would be expected that participants who have experience with high protein products would expect to pay more for this product. This hypothesis was tested by using a t-test to compare the average prices that the participants in the HT group would pay to the prices that the participants in the HNT group would be willing to pay. Since the p-value is 0.012, it is possible to reject the null hypothesis that there is no difference between the two groups. Based on the averages, the HNT group was willing to pay about two dollars more for a box containing 6 popsicles.

Price point is another area where it is important to remember that the average might not be the best way to examine the data. Looking at Figure 4-27, it appears that 12 percent of AP were willing to pay more than $10 for a package containing 6 popsicles. Therefore, depending on the cost to manufacture this product at a large scale, it might be possible to charge a premium and make a large margin selling the product to relatively few consumers. Additionally, if the product is produced at a higher volume, it may be possible to lower the margins per unit in order to increase sales and generate a greater profit overall. Such analysis is beyond the scope of this project, and would require more knowledge of the cost to produce this product, as well as a much more detailed financial analysis of the market.

Chapter 6

Conclusions

It was possible to create a high protein popsicle that achieved the targeted formulation requirements. Overall, the concept of a high protein popsicle seemed to be well received with the target demographic. The majority of participants liked the product concept, regardless of their background with supplements, although there were aspects that have some room for improvement. There was a good deal of positive purchase intent, which indicates that further refining of this product may yield a commercially successful product.

The added sugar in this product should probably be decreased. Although it was added for texture and not taste, the sugar was one of the biggest problems that panelists had with the product. Therefore, a non-nutritive sweetener should be investigated, preferably with the same ability to effect a depression of the freezing point in the same way that sucrose can. It should be noted that participants who had previously tried protein supplements and are therefore more likely to be purchasers of this product were not as concerned with the added sugar content as were those who were outside of this demographic.

Another problem for participants in the sensory evaluation study was the packaging. Participants expressed having difficulty consuming the product, and numerous comments were made expressing discontent with the product's appearance. Therefore, it can be concluded that the current package should be refined considerably before the product goes to market. Many participants suggested packaging the product in a more conventional container or on a stick like a traditional popsicle.

Chapter 7

Recommendations for Future Research

Commercial Sterilization

Making the product shelf-stable was an early goal for this product. Although this is ambitious for a dairy product of this type, being able to distribute the product without it being frozen would be a large plus if this product were to go to retail. Even if stores were to freeze the product once it arrived, shipping the product without it needing to be thermally controlled would save a lot of money in the distribution costs. Additionally, it would open up new potential retail outlets, since many vitamin and supplement stores such as GNC do not currently have refrigerated shelf space in their stores. A comparison of the textural properties for mix that has been retorted compared to product that has been heated to 65-70 ℃ for 35 minutes should be conducted.

Formulation and Packaging

While participants generally seemed to like the product, there were several trends in the comments that should be implemented and tried in the future. Minimizing the amount of added sugar and slightly increasing the chocolate flavor slightly were two areas that could be improved in a new formulation. These changes should be taken into account so that the product can be reformulated. Another sensory study comparing the formula investigated in this study to the new formula based on the results would show if an improvement had been made. Based on the

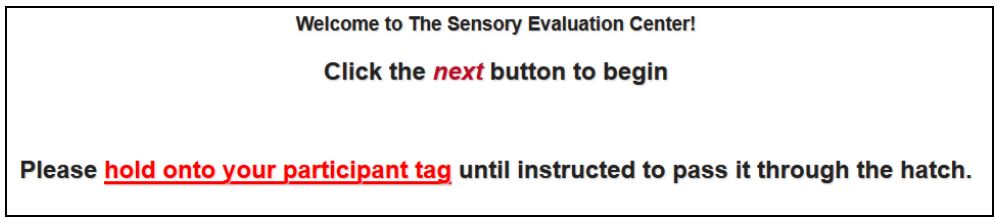
results of this study, another molecule could be used besides sucrose to attempt to depress the freezing point and recreate the texture. Participants should at least be asked for their opinion on the substitute in comparison to sugar to determine which they would prefer to see in the product. Additionally, increasing the amount of cocoa powder would deliver a fuller chocolate taste, and would probably also cut the sweetness so that a smaller percentage of participants will find it to be too sweet.

Additionally, the product's packaging was not well received. Since the product used in this study had a prototype package, the product should be re-evaluated through sensory evaluation with a final version that is easier to open and is opaque. If participants still do not like the tube method of packaging this product, then a more traditional method should be used. Since several participants wanted to see the product in either a more traditional popsicle form on a stick, or in a form more similar to a tub of ice cream, it might be interesting to have a sensory panel evaluate the popsicle in the tube form next to more traditional methods of packaging to see if participants actually prefer these types of packages when they are presented with them.

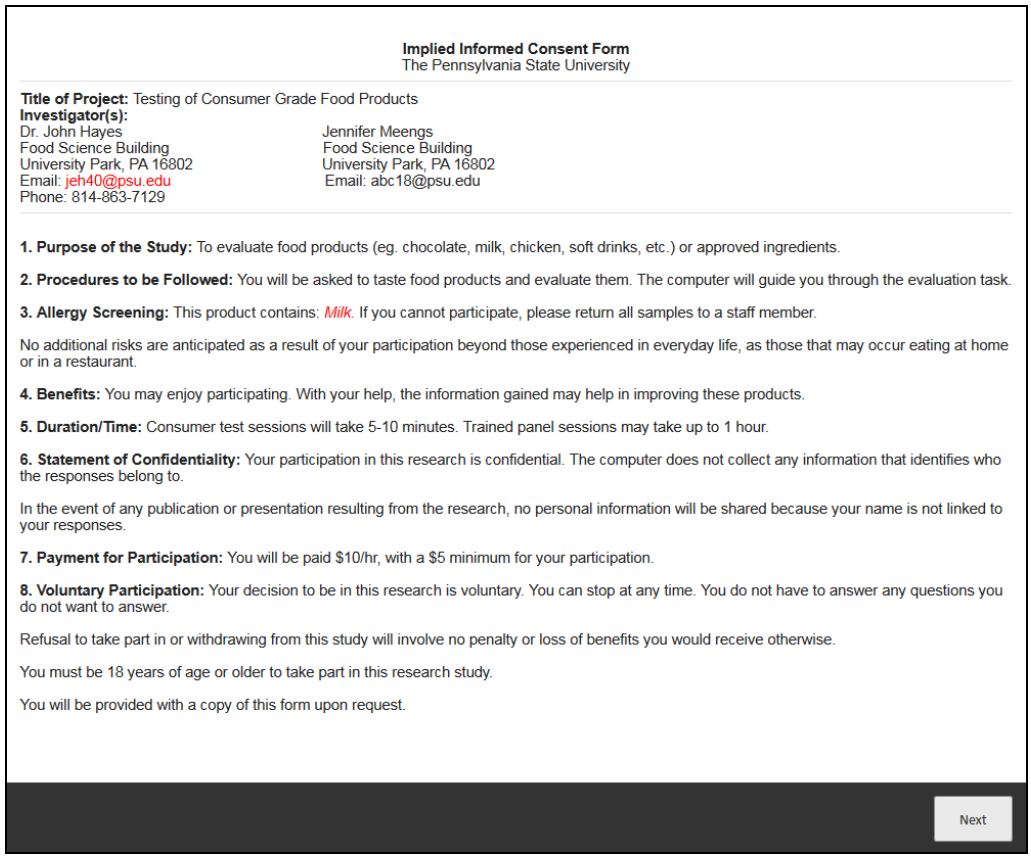
Appendix A

Sensory Study Questionnaire

Shown in this appendix are images of the relevant parts of the screens that participants were shown during the sensory study.



Appendix A - 1: First screen presented to participants in the sensory study.



Implied Informed Consent Form
The Pennsylvania State University

Title of Project: Testing of Consumer Grade Food Products
Investigator(s):

Dr. John Hayes
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1. Purpose of the Study: To evaluate food products (eg. chocolate, milk, chicken, soft drinks, etc.) or approved ingredients.

2. Procedures to be Followed: You will be asked to taste food products and evaluate them. The computer will guide you through the evaluation task.

3. Allergy Screening: This product contains: *Milk*. If you cannot participate, please return all samples to a staff member.

No additional risks are anticipated as a result of your participation beyond those experienced in everyday life, as those that may occur eating at home or in a restaurant.

4. Benefits: You may enjoy participating. With your help, the information gained may help in improving these products.

5. Duration/Time: Consumer test sessions will take 5-10 minutes. Trained panel sessions may take up to 1 hour.

6. Statement of Confidentiality: Your participation in this research is confidential. The computer does not collect any information that identifies who the responses belong to.

In the event of any publication or presentation resulting from the research, no personal information will be shared because your name is not linked to your responses.

7. Payment for Participation: You will be paid $10/hr, with a $5 minimum for your participation.

8. Voluntary Participation: Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer.

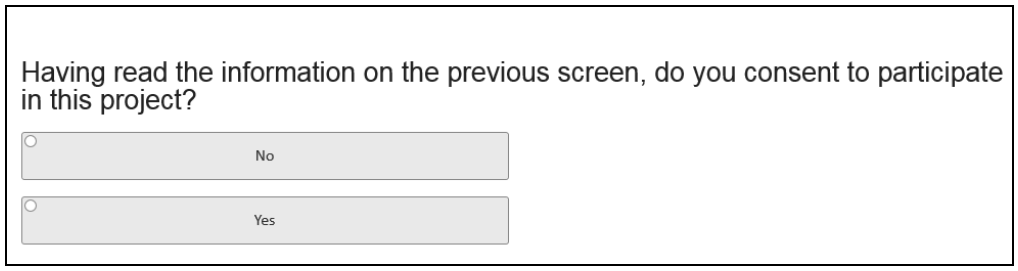
Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

You must be 18 years of age or older to take part in this research study.

You will be provided with a copy of this form upon request.

Next

Appendix - 2: Second screen presented to participants in the sensory study.



Having read the information on the previous screen, do you consent to participate in this project?

No

Yes

Appendix - 3: Third screen presented to participants in the sensory study.

Please take a moment to read the following product description.

The product you are about to sample is a high-protein freezer popsicle. Packaged in a plastic tube, this chocolate-fudge flavored popsicle delivers 20 grams of high-quality whey protein per popsicle. Shown below is an approximate nutrition facts panel for the product.

Nutrition Facts

Serving Size 1 package (100g)
Servings Per Container 1

Amount Per Serving

Calories 190	Calories from Fat 0
	% Daily Value*
Total Fat 0g	**0%**
Saturated Fat 0g	**0%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 0mg	**0%**
Total Carbohydrate 22g	**7%**
Dietary Fiber 1g	**4%**
Sugars 21g	
Protein 20g	

Vitamin A 0%	•	Vitamin C 0%	
Calcium 0%	•	Iron 0%	

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

		Calories:	2,000	2,500
Total Fat	Less than		65g	80g
Sat Fat	Less than		20g	25g
Cholesterol	Less than		300mg	300mg
Sodium	Less than		2,400mg	2,400mg
Total Carbohydrate			300g	375g
Dietary Fiber			25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

Appendix - 4: Fourth screen presented to participants in the sensory study.

After reading about this product, how likely would you be to purchase it if it were available for a reasonable price where you normally shop?

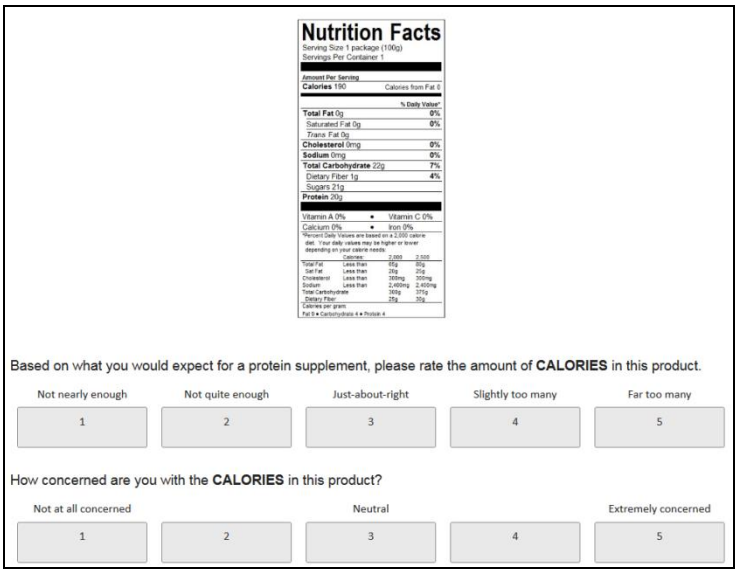
- ○ Definitely would not purchase
- ○ Probably would not purchase
- ○ Might or might not purchase
- ○ Probably would purchase
- ○ Definitely would purchase

Appendix - 5: Fifth screen presented to participants in the sensory study.

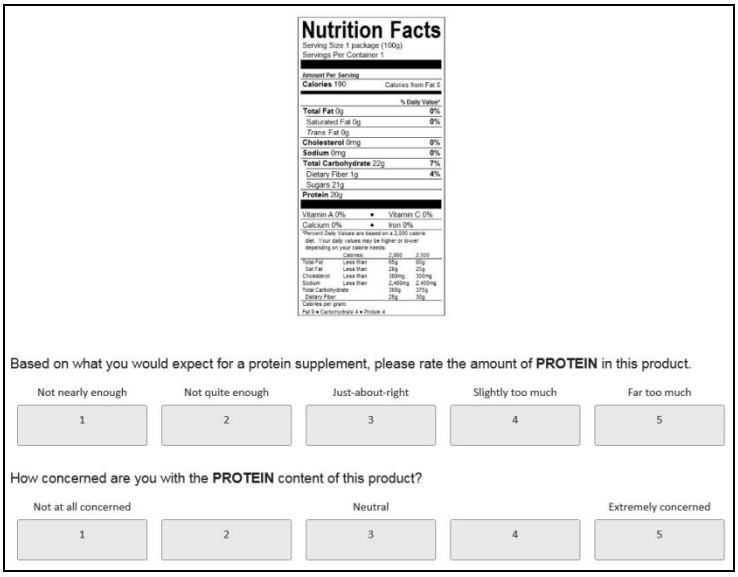
How does this product concept compare to the currently available high protein products?

- ○ Much worse than other high protein products
- ○ Slightly worse than other high protein products
- ○ About the same as other high protein products
- ○ Slightly better than other high protein products
- ○ Much better than other high protein products

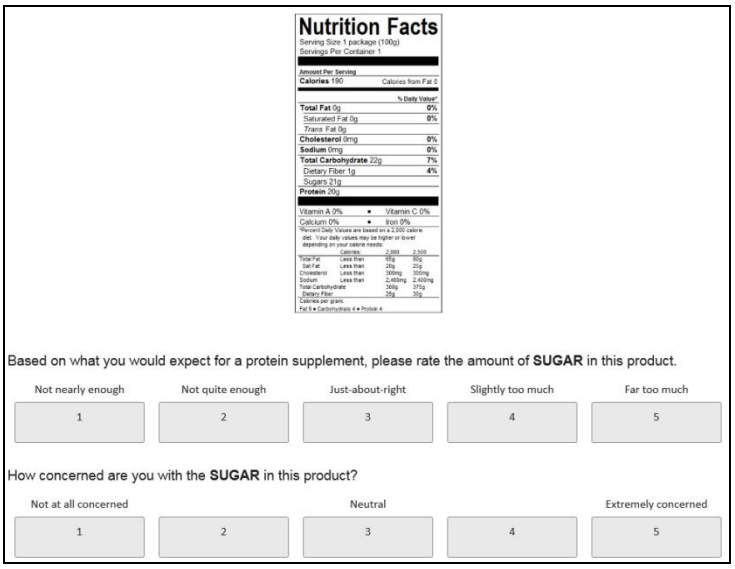
Appendix - 6: Sixth screen presented to participants in the sensory study.



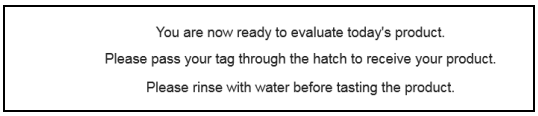
Appendix - 7: Seventh screen presented to participants in the sensory study.



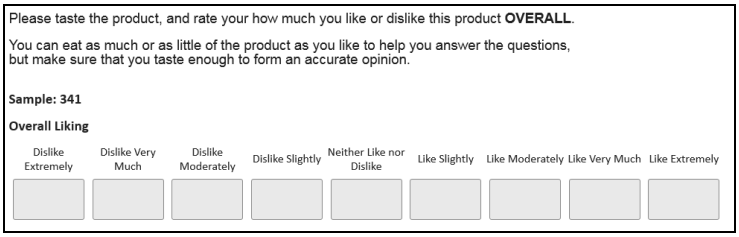
Appendix - 8: Eighth screen presented to participants in the sensory study.



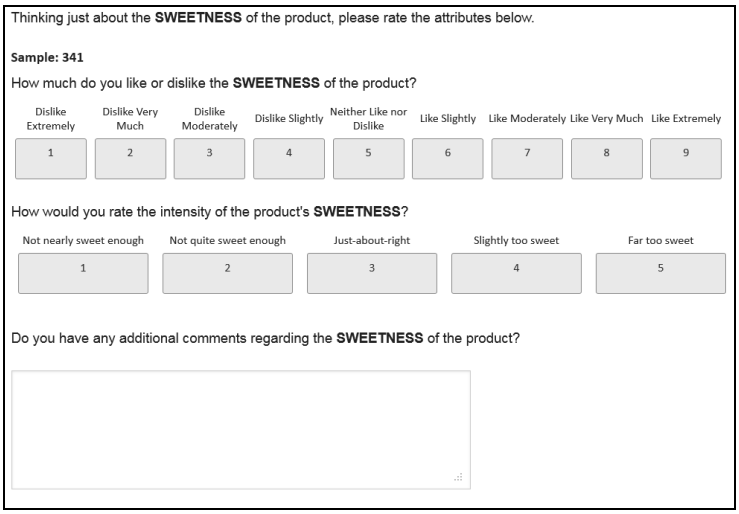
Appendix - 9: Ninth screen presented to participants in the sensory study.



Appendix - 10: Tenth screen presented to participants in the sensory study.



Appendix - 11: Eleventh screen presented to participants in the sensory study.


Thinking just about the **SWEETNESS** of the product, please rate the attributes below.

Sample: 341

How much do you like or dislike the **SWEETNESS** of the product?

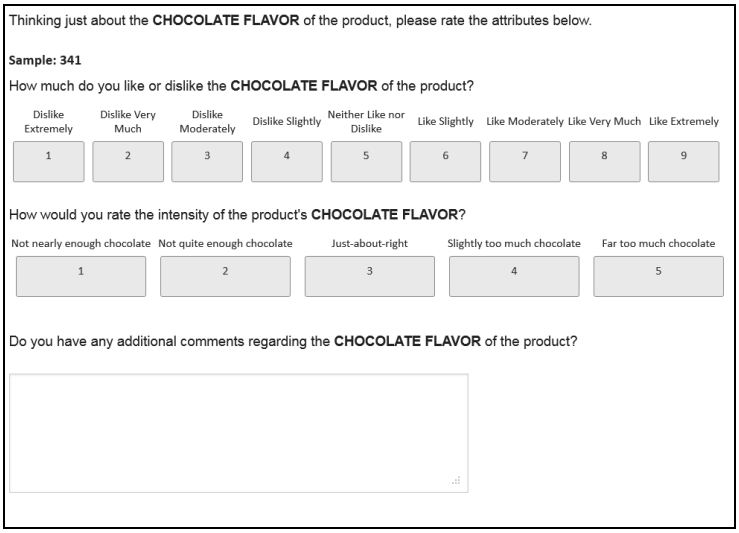
Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
1	2	3	4	5	6	7	8	9

How would you rate the intensity of the product's **SWEETNESS**?

Not nearly sweet enough	Not quite sweet enough	Just-about-right	Slightly too sweet	Far too sweet
1	2	3	4	5

Do you have any additional comments regarding the **SWEETNESS** of the product?

Appendix - 12: Twelfth screen presented to participants in the sensory study.


Thinking just about the **CHOCOLATE FLAVOR** of the product, please rate the attributes below.

Sample: 341

How much do you like or dislike the **CHOCOLATE FLAVOR** of the product?

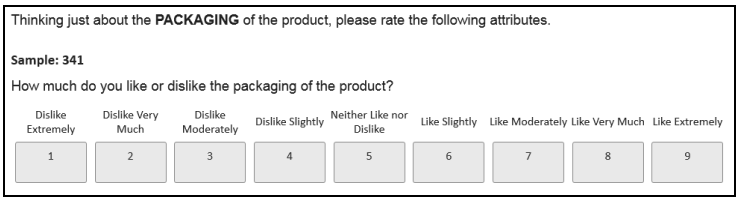
Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
1	2	3	4	5	6	7	8	9

How would you rate the intensity of the product's **CHOCOLATE FLAVOR**?

Not nearly enough chocolate	Not quite enough chocolate	Just-about-right	Slightly too much chocolate	Far too much chocolate
1	2	3	4	5

Do you have any additional comments regarding the **CHOCOLATE FLAVOR** of the product?

Appendix - 13: Thirteenth screen presented to participants in the sensory study.

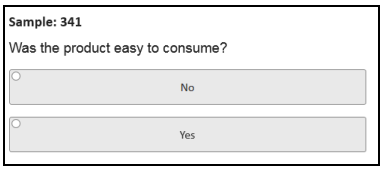

Thinking just about the **PACKAGING** of the product, please rate the following attributes.

Sample: 341

How much do you like or dislike the packaging of the product?

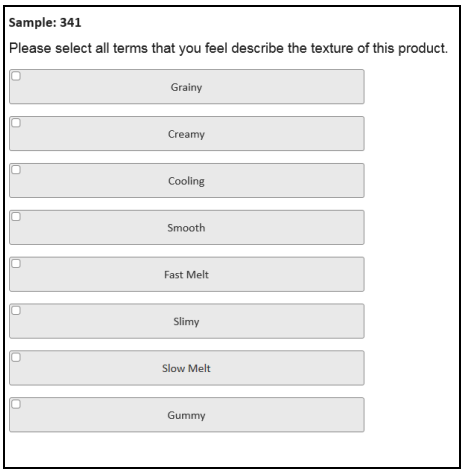
Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
1	2	3	4	5	6	7	8	9

Appendix - 14: Fourteenth screen presented to participants in the sensory study.

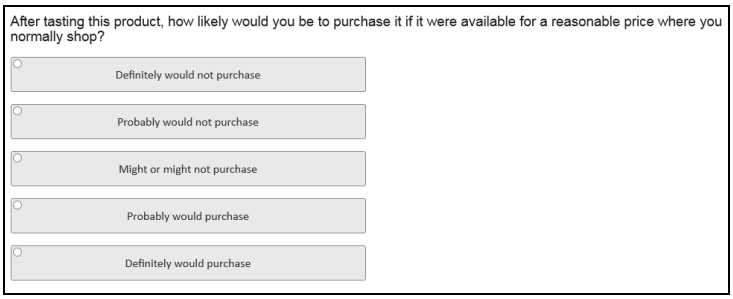


Appendix - 15: Fifteenth screen presented to participants in the sensory study.

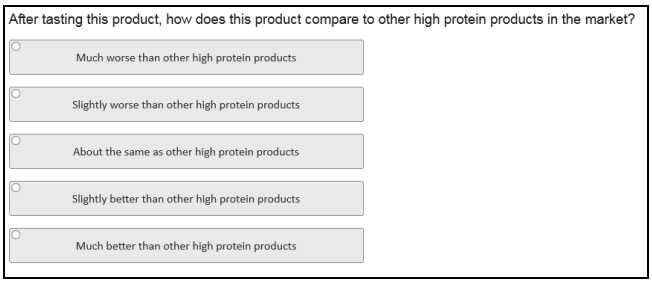
Appendix - 16: Sixteenth screen presented to participants in the sensory study.



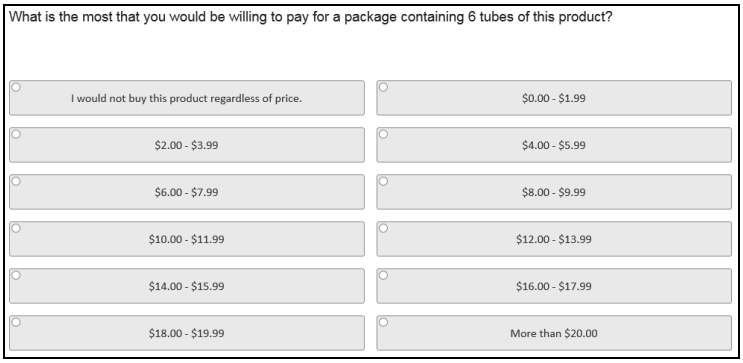
Appendix - 17: Seventeenth screen presented to participants in the sensory study.



Appendix - 18: Eighteenth screen presented to participants in the sensory study.

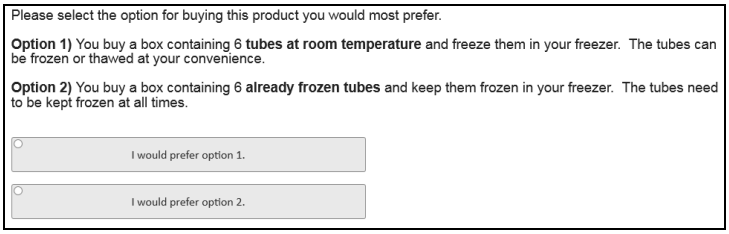


Appendix - 19: Nineteenth screen presented to participants in the sensory study.

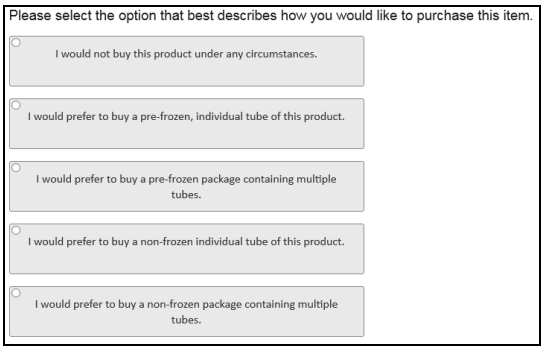


Appendix - 20: Twentieth screen presented to participants in the sensory study.

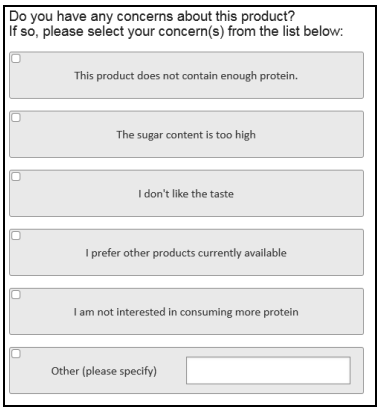
Appendix - 21: Twenty-first screen presented to participants in the sensory study.



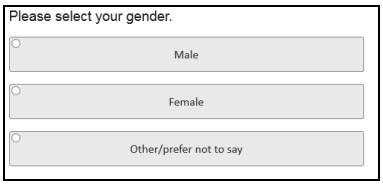
Appendix - 22: Twenty-second screen presented to participants in the sensory study.



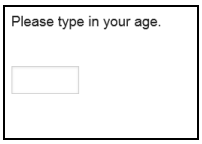
Appendix - 23: Twenty-third screen presented to participants in the sensory study.



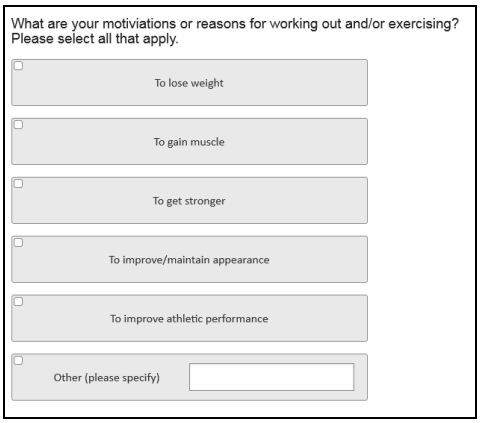
Appendix - 24: Twenty-fourth screen presented to participants in the sensory study.



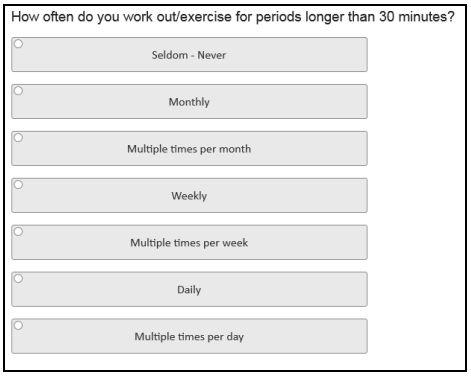
Appendix - 25: Twenty-fifth screen presented to participants in the sensory study.



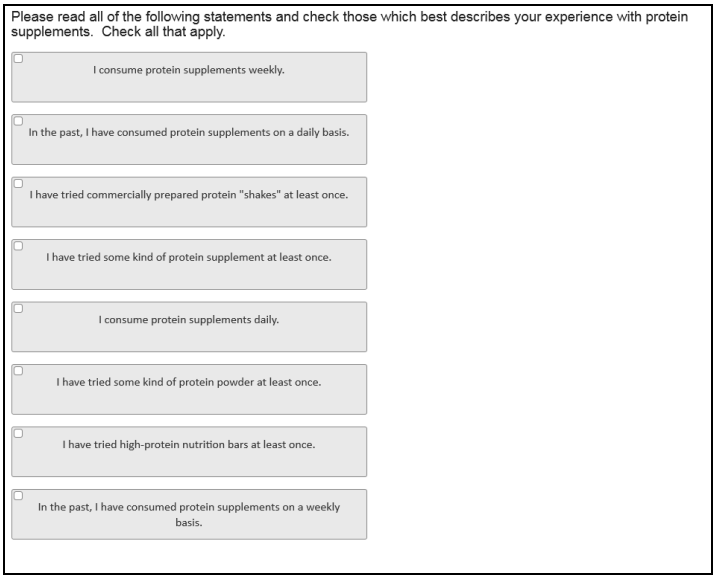
Appendix - 26: Twenty-sixth screen presented to participants in the sensory study.



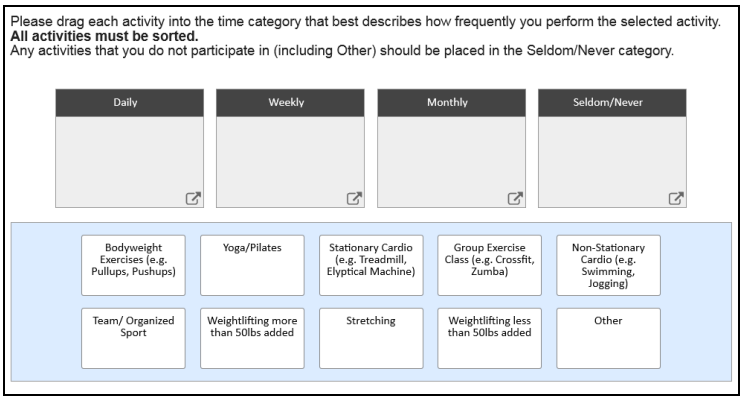
Appendix - 27: Twenty-seventh screen presented to participants in the sensory study.



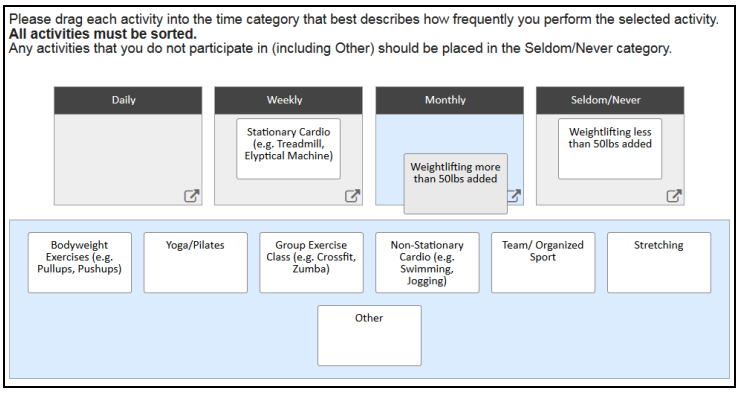
Appendix - 28: Twenty-eighth screen presented to participants in the sensory study.



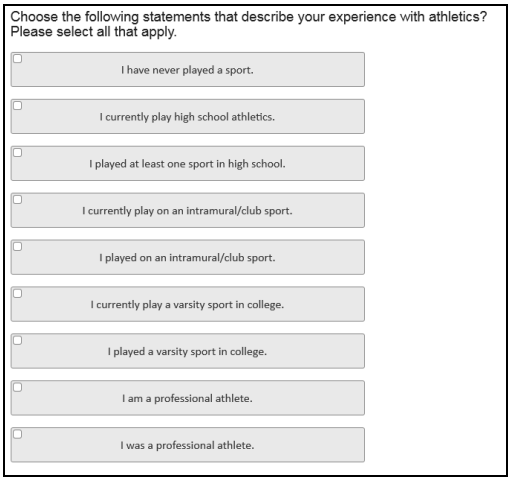
Appendix - 29: Twenty-ninth screen presented to participants in the sensory study.



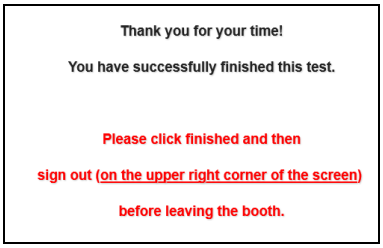
Appendix - 30: Thirtieth screen presented to participants in the sensory study.



Appendix - 31: Thirtieth screen presented to participants in the sensory study. This figure illustrates the participants dropping the categories into bins.



Appendix - 32: Thirty-second screen presented to participants in the sensory study.



Appendix - 33: Thirty-fourth presented to participants in the sensory study.

Appendix B

Statistical Analysis

Presented in this appendix are the results of the statistical analysis performed using Minitab 17 software on the results of the sensory evaluation study.

Two-Sample T-Test and CI: Have Not Tried, Have Tried

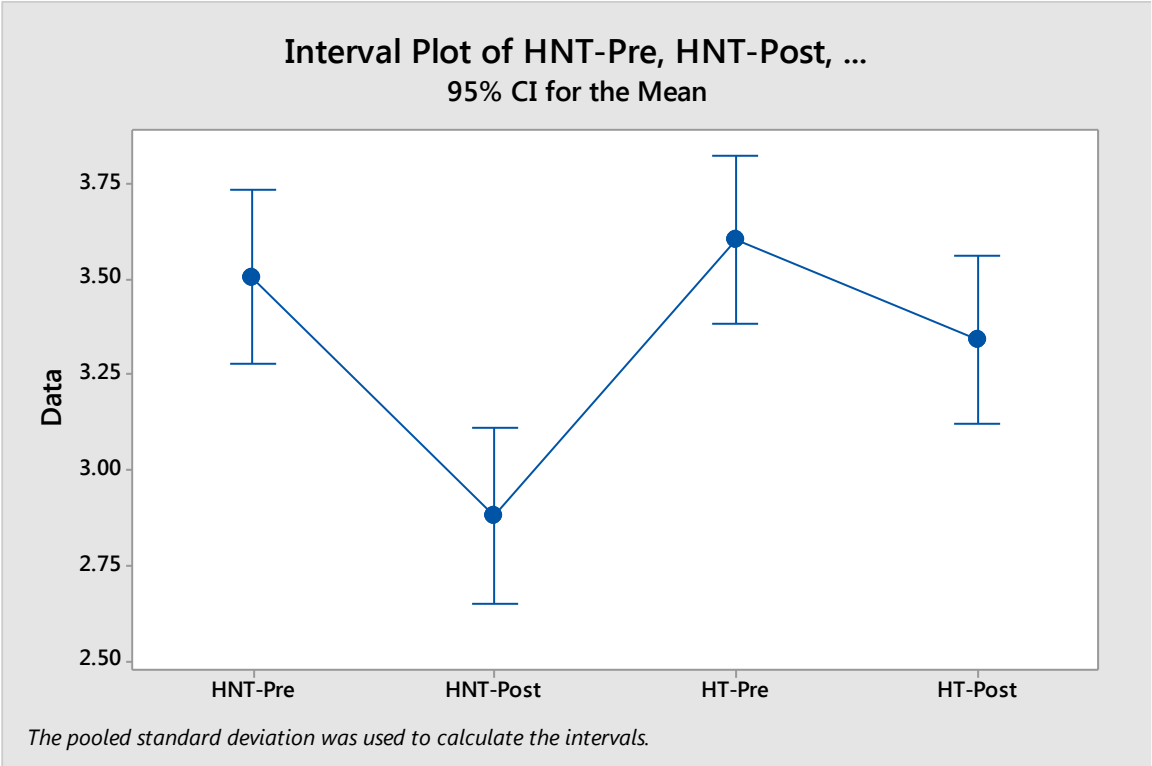
```
Two-sample T for Have Not Tried vs Have Tried

                N   Mean  StDev  SE Mean
Have Not Tried  67  1.687  0.467    0.057
Have Tried      73  1.521  0.503    0.059


Difference = μ (Have Not Tried) - μ (Have Tried)
Estimate for difference:  0.1660
95% CI for difference:  (0.0038, 0.3282)
T-Test of difference = 0 (vs ≠): T-Value = 2.02  P-Value = 0.045  DF = 137
```

Appendix B-1: Results of a T-test comparing the gender of participants in group HT with those in group HNT. This analysis was completed using Minitab 17 Statistical Software. HT is a data set from only those panelists who indicated they previously have tried a high protein product (n=73), while HNT represents those participants who reported they have not tried a high protein product (n=67).

One-way ANOVA: HNT-Pre, HNT-Post, HT-Pre, HT-Post

```
Method

Null hypothesis         All means are equal
Alternative hypothesis  At least one mean is different
Significance level      α = 0.05

Equal variances were assumed for the analysis.


Factor Information

Factor  Levels  Values
Factor       4  HNT-Pre, HNT-Post, HT-Pre, HT-Post


Analysis of Variance

Source   DF  Adj SS  Adj MS  F-Value  P-Value
Factor    3   21.06  7.0197     7.70    0.000
Error   276  251.71  0.9120
Total   279  272.77


Model Summary

       S   R-sq  R-sq(adj)  R-sq(pred)
0.954981  7.72%      6.72%       5.01%


Means

Factor     N    Mean   StDev       95% CI
HNT-Pre   67  3.5075  0.8048  (3.2778, 3.7371)
HNT-Post  67   2.881   1.187  ( 2.651,  3.110)
HT-Pre    73  3.6027  0.7215  (3.3827, 3.8228)
HT-Post   73   3.342   1.044  ( 3.122,  3.562)

Pooled StDev = 0.954981
```

Appendix B-2: Results of the one-way analysis of variance test performed using MiniTab 17 Statistical Software. This test was performed on the HT and HNT data for participants' responses to how likely they were to purchase the product. The question was asked after participants had read a description of the product, but before they were given a sample of the product (Pre), and again after they had had the opportunity to try the product (Post).



Appendix B-3: Interval plot of the results of the one-way ANOVA test for HNT and HT indicating likelihood of purchase.

Tukey Pairwise Comparisons

Grouping Information Using the Tukey Method and 95% Confidence

Factor	N	Mean	Grouping
HT-Pre	73	3.6027	A
HNT- Pre	67	3.5075	A
HT-Post	73	3.342	A
HNT- Post	67	2.881	B

Means that do not share a letter are significantly different.

Appendix B-4: Groupings of the HNT and HT pre and post comparisons ANOVA for likelihood of purchase.

One-way ANOVA: HNT- Pre, HNT- Post, HT-Pre, HT-Post

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Factor	4	HNT- Pre, HNT- Post, HT-Pre, HT-Post

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	3	7.943	2.6477	3.13	0.026
Error	276	233.482	0.8459		
Total	279	241.425			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.919755	3.29%	2.24%	0.45%

Means

Factor	N	Mean	StDev	95% CI
HNT- Pre	67	3.358	0.949	(3.137, 3.579)
HNT- Post	67	3.075	1.034	(2.853, 3.296)
HT-Pre	73	3.3014	0.7938	(3.0895, 3.5133)
HT-Post	73	3.548	0.898	(3.336, 3.760)

Pooled StDev = 0.919755

Appendix B-5: Results of a one-way ANOVA for the results observed when participants were asked to compare this popsicle to other products. The groupings of participants used were HNT-pre, HNT-post, HT-pre and HT-post.

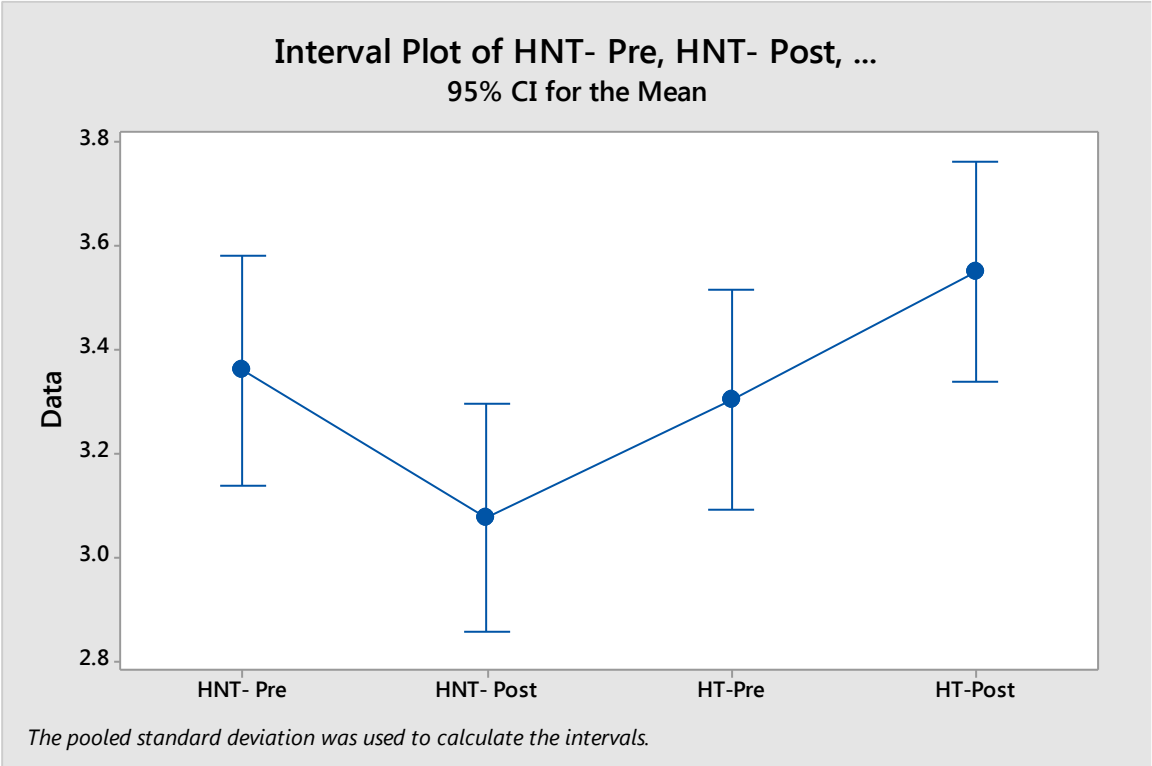
Tukey Pairwise Comparisons

Grouping Information Using the Tukey Method and 95% Confidence

Factor	N	Mean	Grouping
HT-Post	73	3.548	A
HNT- Pre	67	3.358	A B
HT-Pre	73	3.3014	A B
HNT- Post	67	3.075	B

Means that do not share a letter are significantly different.

Appendix B -6: Results of a Tukey pairwise comparison for the results observed when participants were asked to compare this popsicle to other products. The groupings of participants used were HNT-pre, HNT-post, HT-pre and HT-post.



Appendix B -7: Graph showing the confidence intervals for the results observed when participants were asked to compare this popsicle to other products. The groupings of participants used were HNT-pre, HNT-post, HT-pre and HT-post.

Two-Sample T-Test and CI: HT, HNT

```
Two-sample T for HT vs HNT

      N  Mean  StDev  SE Mean
HT   73  6.70   1.69     0.20
HNT  67  5.91   1.80     0.22


Difference = μ (HT) - μ (HNT)
Estimate for difference:  0.788
95% CI for difference:  (0.204, 1.373)
T-Test of difference = 0 (vs ≠): T-Value = 2.67  P-Value = 0.009  DF = 135
```

Appendix B -8: Results of a t-test comparing the HT and HNT responses for their overall liking of the product.

Two-Sample T-Test and CI: HT, HNT

```
Two-sample T for HT vs HNT

      N  Mean  StDev  SE Mean
HT   73  6.53   1.63     0.19
HNT  67  6.15   1.72     0.21


Difference = μ (HT) - μ (HNT)
Estimate for difference:  0.385
95% CI for difference:  (-0.176, 0.946)
T-Test of difference = 0 (vs ≠): T-Value = 1.36  P-Value = 0.177  DF = 135
```

Appendix B -9: Results of a t-test comparing the HT and HNT responses for their liking of the chocolate flavor of the product.

Two-Sample T-Test and CI: HT, HNT

```
Two-sample T for HT vs HNT

      N  Mean  StDev  SE Mean
HT   73  6.45   1.50     0.18
HNT  67  6.13   1.78     0.22


Difference = μ (HT) - μ (HNT)
Estimate for difference:  0.318
95% CI for difference:  (-0.236, 0.871)
T-Test of difference = 0 (vs ≠): T-Value = 1.14  P-Value = 0.258  DF = 129
```

Appendix B -10: T-test comparing the averages for HT and HNT liking of sweetness.

Two-Sample T-Test and CI: HT, HNT

```
Two-sample T for HT vs HNT

      N  Mean  StDev  SE Mean
HT   73  4.66   2.11     0.25
HNT  67  4.61   1.99     0.24


Difference = μ (HT) - μ (HNT)
Estimate for difference:  0.046
95% CI for difference:  (-0.640, 0.731)
T-Test of difference = 0 (vs ≠): T-Value = 0.13  P-Value = 0.896  DF = 137
```

Appendix B -11: T-test comparing packaging between the HT and HNT groups. Analysis was conducted by assigning a numeric value to each category.

Two-Sample T-Test and CI: HT, HNT

```
Two-sample T for HT vs HNT

      N   Mean  StDev  SE Mean
HT   73  3.192  0.544    0.064
HNT  67  3.239  0.630    0.077


Difference = μ (HT) - μ (HNT)
Estimate for difference:  -0.0470
95% CI for difference:  (-0.2446, 0.1506)
T-Test of difference = 0 (vs ≠): T-Value = -0.47  P-Value = 0.639  DF = 131
```

Appendix B -12: Results of a t-test comparing the results of a just-about-right scale for calories between the HT and HNT groups.

Two-Sample T-Test and CI: HT, HNT

```
Two-sample T for HT vs HNT

      N  Mean  StDev  SE Mean
HT   73  2.75   1.19     0.14
HNT  67  2.78   1.28     0.16


Difference = μ (HT) - μ (HNT)
Estimate for difference:  -0.023
95% CI for difference:  (-0.436, 0.391)
T-Test of difference = 0 (vs ≠): T-Value = -0.11  P-Value = 0.914  DF = 134
```

Appendix B -13: Results of a t-test comparing the HT and HNT results for concern over the amount of calories in this product.

Two-Sample T-Test and CI: HT, HNT

```
Two-sample T for HT vs HNT

      N  Mean  StDev  SE Mean
HT   73  36.1   13.1      1.5
HNT  67  36.4   13.0      1.6


Difference = μ (HT) - μ (HNT)
Estimate for difference:  -0.30
95% CI for difference:  (-4.66, 4.07)
T-Test of difference = 0 (vs ≠): T-Value = -0.13  P-Value = 0.893  DF = 137
```

Appendix B -14: Results of a t-test comparing the average age of participants in the HT and HNT groups.

One-way ANOVA: Under 30, HT, HNT, Over 30

```
Method

Null hypothesis         All means are equal
Alternative hypothesis  At least one mean is different
Significance level      α = 0.05
Rows unused             40

Equal variances were assumed for the analysis.


Factor Information

Factor  Levels  Values
Factor       4  Under 30, HT, HNT, Over 30


Analysis of Variance

Source   DF  Adj SS  Adj MS  F-Value  P-Value
Factor    3   25.42   8.473     2.73    0.044
Error   276  855.65   3.100
Total   279  881.07


Model Summary

      S   R-sq  R-sq(adj)  R-sq(pred)
1.76074  2.88%      1.83%       0.04%


Means

Factor     N   Mean  StDev      95% CI
Under 30  60  6.133  1.827  (5.686, 6.581)
HT        73  6.699  1.689  (6.293, 7.104)
HNT       67  5.910  1.798  (5.487, 6.334)
Over 30   80  6.463  1.743  (6.075, 6.850)

Pooled StDev = 1.76074
```

Appendix B -15: Shown are the results of a one-way ANOVA comparing the average overall likings of HT, HNT, participants under 30 and participants over 30.

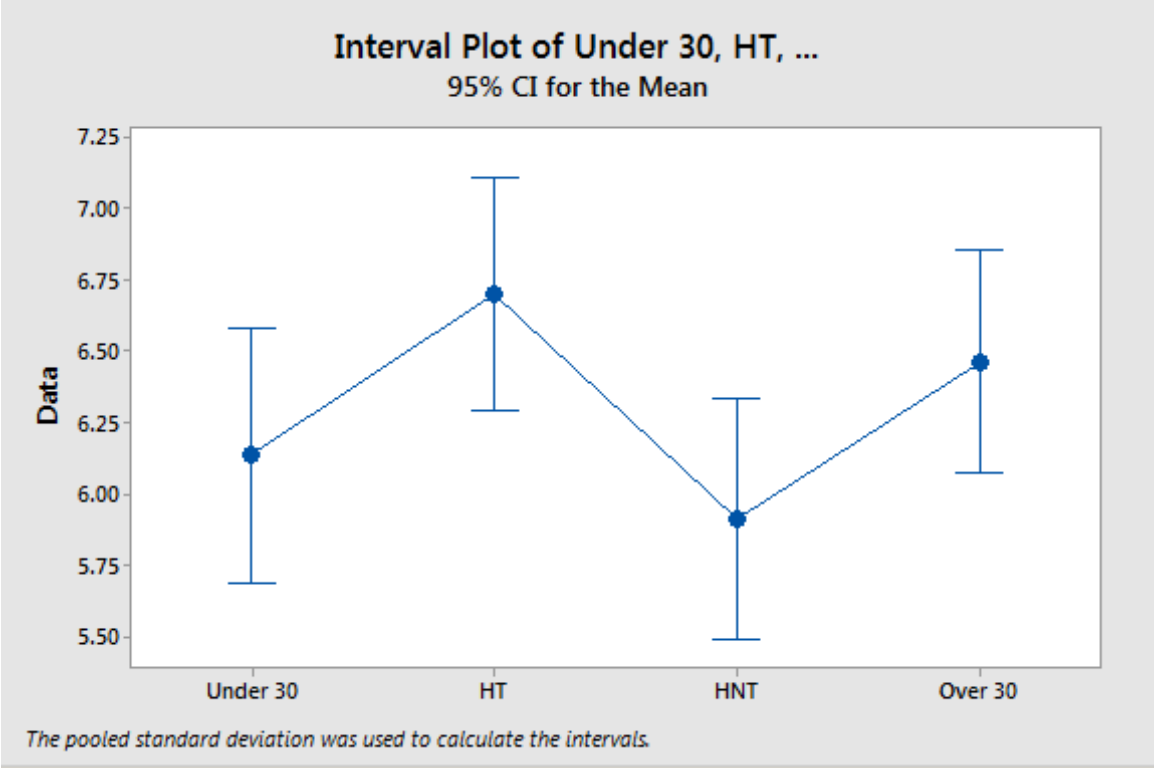
Tukey Pairwise Comparisons

Grouping Information Using the Tukey Method and 95% Confidence

Factor	N	Mean	Grouping
HT	73	6.699	A
Over 30	80	6.463	A B
Under 30	60	6.133	A B
HNT	67	5.910	B

Means that do not share a letter are significantly different.

Appendix B -16: Groupings based on a Tukey comparison of the average overall likings of HT, HNT, participants under 30 and participants over 30.



Appendix B -17: Graph showing the confidence intervals for the ANOVA test which compared the overall liking scores for the HT, HNT, participants under 30, and participants over 30 groups.

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Hopkinton High School, Hopkinton, MA — Spring 2010

Work Experience:

Baby's Burgers and Shakes — May 2014 – July 2015
Line Cook

- Preparing and expediting food as part of a team

Teaching Assisting
NUTR 386 and FD SC 410 Teaching Assistant — Fall 2014; Spring 2015

- Assisted with grading, answering questions, and facilitating laboratory activities

English 495 Internship — Spring 2012, Fall 2013
Tutor

- Worked with adult learners to enhance understanding of English, math and life skills

University of Cordoba – Department of Cellular Biology, Cordoba, Spain — Summer 2013
Research Intern

- Managed research project examining relationship between obesity and breast cancer

Penn State Athletics Fencing Camp, University Park, PA — Summer 2011, 2012
Counselor

- Provided leadership and guidance to pre-college athletes during two-week camp

IPSEN Pharmaceuticals, Milford MA — Summer 2009
Legal Department Intern

- Assisted in preparing and organizing information in advance of a major legal deposition

Extra-Curricular:

Penn State Varsity Fencing Team — Fall 2010 - Spring 2014
Position: Epee Squad

- Individual record of 12 wins 8 losses (Varsity Letter Recipient); 2014 NCAA Champions

The Daily Collegian (Penn State Student Newspaper)

Candidate Campus Reporter	Spring 2012 Fall 2012	*General Assignment Reporter* *Campus Enterprise Reporter*	Summer 2012
Campus Education Reporter *Monday Columnist*	Spring 2014	*Opinions Editor and StateViews Editor*	Spring 2013 Fall 2014

Penn State IFC/Panhellenic Dance MaraTHON
Morale Committee Member — Fall/Spring 2010 - 11, 2012-13, 2013-14

- Provided physical and emotional support for dancers THON weekend

Communications Committee Member — Fall/Spring 2011 - 12

- Aided in coordinating special projects and events leading up to THON weekend

Honors First-Year Testing, Consulting, and Advising Program — Summer 2012
Mentor

- Selected to welcome new honors students and assist with first semester scheduling

Specialized

Excellence in Communication Certificate — Spring 2015

- Earned by demonstrating superior oral, written, visual, and electronic

Training:

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Ice Cream 101 Spring 2015

- Teaching assistant and participant in a weekend introductory course on ice-cream related concepts

Ice Cream Short Course January 2015

- Photographer and participant in a weeklong course focused on commercial ice cream manufacture

Principles of HACCP Certification Fall 2014

- Introductory course in managing a HACCP plan, certified by the International HACCP Alliance

PNC Leadership Assessment Center Fall 2012

- Program designed for honors students to improve leadership ability

Honors and Awards:

2nd Place Keystone Student Press Award- Collection of Editorials	Spring 2015
Penn State Summer Discovery Grant	Summer 2013
Paterno Fellow – Schreyer Honors College	Spring 2011 - Present
Dean's List Academic Achievement	Spring 2011 - Fall 2013
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