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DETERMINATION OF A SUITABLE SENSORY PROTOCOL(S) TO CHARACTERIZE FROZEN DAIRY-BASED PRODUCTS

BY

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DECLARATION

This is to certify that this thesis is the result of research undertaken by Priscilla Fathia Ahadzi towards the award of the Master of Philosophy in Food Science in the Department of Nutrition and Food Science, University of Ghana.

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ABSTRACT

Sensory evaluation is a useful tool in the food and non-food industries. Sensory evaluation of frozen desserts including polyethylene packed ones popularly found in Ghana are greatly affected by serving temperatures. Frozen desserts have been assessed with static methods like Quantitative Descriptive Analysis (QDA®) but the temporal perceptions throughout consumptions are rarely covered. With food companies weary of the time intensive nature of descriptive methods like QDA® and challenges with sensory evaluations of frozen desserts, this study sought to determine a suitable serving temperature and profiling test method for the characterization of dairy-based frozen desserts packaged in plastic pouches through Ghanaian consumer insights. Through a consumer survey, frozen hard, slushy and liquid were identified as the 3 physical forms that frozen dairy-based desserts in plastic pouches were consumed. The mode of consumption and the time taken for Ghanaians to consume such desserts were also investigated. One of the popular plastic sachet packaged frozen desserts on the Ghanaian market, a chocolate flavoured milk frozen dessert was used for the study. Thawing test under different environmental temperatures provided the corresponding serving temperatures of -10 °C± 2°C, -4°C ± 2°C and 4°C ± 2°C to frozen, slushy and liquid states respectively. A consumer acceptance test by Ghanaians on the 3 physical forms using the 9-point hedonic scale was used to determine the highest point of liking throughout the consumption exercise i.e. at first taste, mid-way of consumption and at the end of consumption. The sensory profiles of the frozen desserts served in the 3 physical forms were also determined using QDA®, Temporal Dominance of Sensation (TDS) and Temporal Check All That Apply (TCATA).

The survey showed that Ghanaians mostly consumed such products in the slushy state and rarely in the liquid state, and they did so by taking bites and not sucking the juices out of the iced product.

The serving temperatures and by extension the physical forms resulted in significant differences ($p \leq 0.05$) in sensory characteristics and consumer liking of the frozen dessert.

Consumer liking scores were highest at the end of the consumption experience. Ghanaian consumers liked the frozen dessert in the liquid state the most followed by the slushy state.

QDA® demonstrated sensory differences with the slushy state sharing attributes in common with the frozen and liquid states. The frozen state showed low perceptions of taste and flavour notes while the opposite was observed for the liquid state except for bitter taste, which had a higher intensity in the frozen state.

The temporal methods TDS and TCATA were comparable to QDA® in determining the sensory profile of the product at different serving temperatures while capturing the temporal essence of the perceptions. TDS focused on the dominant attributes and had intensity scores that were comparable to QDA® scores. TDS can be useful in characterizing original or improved products. TCATA provided a much complete qualitative profile of the frozen desserts in the different physical forms. It can be a useful tool in capturing subtle off notes and evaluation of new or improved products. The two temporal methods were relatively faster to execute and required less amount of product compared to QDA®.

DEDICATION

I dedicate this research work to the Almighty God for how far He has brought me, my family, the Sensory Evaluation Laboratory, Danone Nutricia Research and Fan Milk Ghana Limited, and my best friend; Dr. Samuel Amoafo-Harrison.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND

Frozen desserts are a class of dairy or non-dairy desserts consumed in the frozen state and often as a snack and for general refreshments. Globally, ice cream is the most consumed and popular frozen dessert. Others include frozen yoghurt, sherbets and sorbets. The most popularly consumed commercial frozen desserts in Ghana are ice cream, frozen yoghurt and sherbets of different flavours including chocolate. These are relatively affordable and come packaged in polyethylene pouches. Although the frozen desserts found on the Ghanaian market are mainly from large production companies and imports, some small to medium scale food companies, restaurants and cafes also venture into artisanal frozen desserts. Sensory evaluation of foods including frozen desserts help producers understand how the physicochemical outcomes imparted by their ingredients, processes and handling translate into the sensory quality of the finished product and where the need be, how to optimize to achieve perfection (Goff & Hartel, 2013).

Sensory evaluation is a scientific discipline that provides guidelines used to draw out stimuli, measure, analyse and interpret those responses to characteristics of foods and other materials elicited through the senses of sight, smell, taste, touch and hearing. It plays a vast role in product development and determination of the quality of foods and non-foods. Depending on the objectives, sensory evaluation uses an array of people ranging from a panel of very few people who are trained or screened to several hundreds of untrained assessors to carry out assessments (Lawless & Heymann, 2010).

Sensory testing methods are categorized into 3 groups namely the difference, descriptive and consumer tests. The difference test also known as discrimination test is the simplest of sensory

tests and seeks to identify if there are any perceptible differences present between products. This analytical test uses assessors selected for their sensory acuity to common differences in products (Lawless & Heymann, 2010). Consumer testing comes in different forms and depending on the sub-objective, the choice of focus discussion, consumer acceptability or preference etc. can be suitable to achieve the overall objective, and often involves the use of a large number of consumers or regular users of the product group. Descriptive analysis measures the perceived intensities of the sensory characteristics of a product. The panel size is the least among the 3 test categories and uses screened and highly trained assessors.

Quantitative descriptive analysis (QDA®) developed by (Stone, Sidel, Oliver, Woolsey & Singleton, 1974) is one of the widely used descriptive sensory methods for understanding the sensory profile of products and explaining sensory differences. QDA® provides in-depth information about the characteristics of the product holistically with strong correlation with instrumental methods (Breuil & Meullenet, 2007; Villanueva-Carvajal *et al.*, 2012). This method like the other conventional descriptive methods such as Spectrum Analysis are time and money consuming due to long training periods. There is a shift towards novel methodologies known as rapid methodologies, which develop and adopt less time-consuming and relatively inexpensive sensory techniques. These involve the use of either trained or untrained panel to characterize the profile of products but spend little to no time on training. Free Choice Profiling, Projective mapping (Napping®), Flash Profiling and Check-all-that-apply (CATA) are examples of such novel methodologies (Varela & Ares, 2012).

The perception of stimulus during an intake of food is rather dynamic than static where attributes and intensities of the product evolve with time. With this new development, sensory assessment of food has begun to shift towards another group of novel and rapid methodologies that capture

the temporal profile of foods as they provide a dimension that conventional descriptive analyses and the aforementioned rapid methods might miss (Cliff & Heymann, 1993).

In sensory evaluation of food, apart from the test methods, several other components must be considered in executing the sensory tests. The type of panel, the quantity of products to be sampled and how it is to be presented, serving temperature of the product and the tasting environment can greatly affect the outcome of the test. The control of these components are very much influenced by the product just as much as the objective of the test.

1.2 PROBLEM STATEMENT

The need for descriptive data in a fast-paced industrial practice is now very diverse, often placing a great deal of demand on sensory services due to stakeholders' objectives. The cost for precision and consistency of conventional profiling methods is time thus sensory departments that rely only on conventional profiling often cannot be swift enough to achieve project timelines as decisions in industry are often taken on 'go no-go' basis. There are increasing concerns by food companies who invest in sensory information about the worth of time and investment in the use of conventional methods, and these stakeholders are resonating towards rapid and cheaper methods (Delarue, 2015; Varela & Ares, 2012).

A real life situation recently encountered was in the Sensory Evaluation Laboratory at the University of Ghana where sensory evaluation of frozen desserts packaged in polyethylene pouches (sachets) was being done. A major challenge that was observed was selecting the physical state and serving temperature that best displayed the profile of the products. These products were always served in the liquid form around 4°C and assessed using the QDA® method which takes about 9-12 weeks to be completed. This created an opportunity to investigate if some important

sensory information was lost due to the serving temperature and physical state of such products. Also due to the transient state of frozen desserts, a proposed theory was to characterize the profile of those products using temporal methods and investigate the evolution of the perception of sensory notes as the product melted in the mouth and was swallowed.

From observations, consumer tests of dairy-based desserts by the Sensory Evaluation Laboratory have always been conducted in the frozen form. Although assessors are asked to consume the products as they normally would, it appeared that even if the person preferred the product in a particular physical form i.e. slushy or liquid, in order not to waste time, they may still go ahead to consume the product in the frozen form. This could affect the liking scores provided and further not provide actionable information about purchase behaviour and real life consumption situations.

Frozen desserts packaged in polyethylene pouches (commonly called sachets/rubber in local slang) are widely consumed in Ghana. Although American Society for Testing and Material [ASTM E1871] (2008) has proposed frozen desserts to be served at -18°C to -10°C, there is little to no published information on the serving temperatures, physical states and sensory test methods that can best characterize the properties of these unique products on the Ghanaian market.

1.3 RATIONALE

In Ghana, the widely consumed frozen desserts are largely solid-frozen flavoured milk products that come packaged in polyethylene pouches. Such products are highly affected by temperature and time during sensory testing, thus rapid test methods could be useful in evaluations to save time and also money as the longer testing takes to be completed, the more expensive the test becomes. There have been no published studies on other frozen desserts except soft ice cream, resulting in scarce information on the serving temperature of these products. With food companies leaning

towards rapid test methods to save time and money, they remain unaware of the value of temporal methods as suitable rapid test methods to characterize their products as these tests capture the dynamic sensory perception during the food consumption process. It is key to determine a protocol(s) for sensory characterization of these frozen dairy-based desserts to address this industrial need.

1.4 OBJECTIVES

1.4.1 Main objective

To determine suitable sensory protocols to characterize frozen dairy-based desserts.

1.4.2 Specific objectives

i. To determine the consumption style of frozen dairy-based desserts packaged in a plastic pouch.
ii. To identify temperatures that correspond with the changes of the dessert during thawing.
iii. To identify the point during consumption that consumer liking is the highest.
iv. To determine the optimum temperature for the profiling of the frozen dessert.
v. To establish the pros and cons of using different profiling methods to characterize frozen dairy-based desserts.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 FROZEN DESSERTS

Frozen desserts comprise of dairy and non-dairy desserts that are typically aerated and meant to be consumed frozen. Ice creams, then referred to as 'cream ice', founded by the Chinese and Romans, have been in existence since the medieval period when iced beverages and water ices were made using snow (Jana et al., 2016). As ice cream revolutionized, the term was used to classify other types of frozen desserts that had emerged. With established standards, classifying frozen desserts as 'ice creams' is a misnomer as ice cream is technically an example of a frozen dessert. Ice cream must contain at least 10% by weight of milk fat and have no protein source or other non-dairy fat (Kilara & Chandan, 2016). Some examples of other frozen desserts include sherbets, sorbets, ice pops, frozen yogurts, and non-dairy frozen desserts (Goff, 2018; Krahl et al., 2016; O'Sullivan, 2017). A sherbet is a frozen dessert with a lower milk content and a much greater sugar content than ice cream (up to 50%) and at least twice as acidic. Therefore, the product is tarter and sweeter than ice cream. A sorbet is comparable to a sherbet only that it is a non-dairy frozen dessert (Jana *et al.*, 2016; Krahl et al., 2016). Ice pops (popsicles) are dairy or non-dairy frozen desserts on a stick (Contreras et al., 2012). There now exists several variants of frozen desserts including sugar and fat reduction or replacements and addition of probiotics as an alternative for the health-conscious consumer (Jana et al., 2016) thus increasing the market share of frozen desserts.

Many individuals around the globe including Ghanaians consume ice cream and other frozen desserts as a snack, primarily for their sensory characteristics especially the cold sensations and

sweet taste that provide refreshments and contrast to the warmth of other foods (Goff & Hartel, 2013; Kilara & Chandan, 2016). The ice cream, sherbet, frozen yogurt, sorbets and simple frozen flavoured milk beverages are popular frozen desserts on the Ghanaian market. Frozen desserts are available in restaurants, convenience stores, supermarkets and hawked by sellers riding bicycles with chilling box or compartment attached. The production and retail of frozen desserts on the Ghanaian market range from home/artisan made; large manufacturing companies like Fan Milk Ghana Limited; to imported ones. Sensory evaluation is an essential tool for producers and retailers to appreciate and monitor the quality characteristics of their frozen desserts for quality control purposes as well as meeting consumer expectations (Goff & Hartel, 2013). There is almost non-existent published information on the history and evolution, as well as production, consumption trends and sensory evaluation of frozen desserts in Ghana. Most of the frozen desserts found in Ghana come packaged in cups, containers or polyethylene pouches popularly called sachets in the local jargon. Throughout this document the words 'polyethylene pouches', 'plastic pouches', 'plastic sachets', 'sachets' would be used interchangeably to mean the same thing.

2.2 SENSORY EVALUATION

Sensory evaluation is defined as a "scientific discipline used to evoke, measure, analyse and interpret those reactions to characteristics of foods and materials as perceived through the senses of sight, smell, taste, touch and hearing" (Stone & Sidel, 2004). Sensory evaluation committees such as the ASTM and Institute of Food Technologists (IFT) have endorsed this definition. As a science it is executed with an experimental design like all scientific undertakings and contrary to other testing methods which involve the use of various instruments and equipment, this discipline involves the use of a panel of human assessors as its equipment. Outcomes of tests are recorded

based on the panel responses of their sensory perceptions to the products being tested. Statistical analysis is then used to draw inferences and insights regarding the products or consumer trends. Moving forward, the paper will talk in relation to food.

Food products are commonly assessed based on their appearance, aroma, flavour, texture in hand (tactile), texture in mouth (mouth feel) as well as aftereffects (aftertaste). Sensory evaluation is useful in determining the quality of products, in guiding product development and improvement efforts, quality control, advertised claim substantiation, as well as understanding and predicting consumer trends and their markets (Lawless & Heymann, 2010; Kemp et al., 2018). Sensory evaluation tests are grouped as product-oriented (analytical) tests, which answer questions pertaining to the product in itself and consumer-oriented tests that address questions from the consumer point of view. Several categories of people can carry out the evaluation of food. For analytical tests such as descriptive and discrimination tests, a panel of very few people who are trained or screened to be able to identify, define and quantify, and detect product attributes and differences are used. Up to several hundreds of untrained assessors are used for consumer-oriented tests in the case of affective or hedonic tests (Lawless & Heymann, 2010). Altogether, the three basic types of quantitative sensory evaluation tests are affective, discrimination and descriptive tests with each type designed to answer a specific kind of question.

Hedonic or affective tests are used to quantify the preference or degree of liking of a product. Untrained assessors, who are consumers of that product group, indicate their liking on structured or unstructured scales. The nine-point hedonic scale is commonly used, although other lengths of scale and other systems for judging consumer responses are available. Alternative scales include purchase intent scales and preference ranking scales.

Discrimination tests are useful to determine if there are perceivable differences between products using tests such as duo-trio, triangle or paired comparison (Lawless and Heymann, 2010; Meilgaard et al., 2015). These tests usually use 15 to 40 screened assessors and results are presented as proportions or frequencies of correct choices of the test sample from a set of control or similar products.

Descriptive analysis or profiling is used to measure perceived intensities of product characteristics. It uses a trained panel that agrees on the attributes or descriptors to be evaluated and then give intensity scores for each attribute. Widely used methods include Quantitative Descriptive Analysis (QDA®) and the Spectrum Method® (O'Sullivan, 2017).

2.2.1 Role of consumers in product characterization

Consumer acceptance is useful in product development and optimization. It also provides information to develop useful relationships between sensory variables and product liking so that an optimum product can be achieved (Del Giudice & Pascucci, 2010). By understanding consumer needs, new products that offer added consumer value are noticeably warranted to be successful. Consumer sensory data have in recent times driven product development and improvement efforts by providing rich information on consumers' wants and market trends (Horvat et al., 2019). Notwithstanding this apparent significance, several studies have shown that consumer methodologies are underused even in procedures of product development. (van Kleef, 2014).

2.2.2 Quantitative Descriptive Analysis (QDA®)

Sensory descriptive analysis has proven to be the most comprehensive, informative and extensively used tool in sensory science. Food businesses routinely adopt descriptive profiling to qualify and quantify the sensory characteristics of products. Information provided by

understanding the sensory characteristics of products help make informed business decisions; guide product development and improvement efforts to match consumer needs; get nearer to a benchmark; monitor the influence of ingredients or processes, quality control purposes, product changes over time; substantiate claims; and correlate with instrumental analyses (Lawless & Heymann, 2010; Varela &Ares, 2012; Kemp et al., 2018, Beeren, 2018).

Some profiling methods include Quantitative Descriptive Analysis (QDA®) (Stone & Sidel, 2004), Spectrum method ® (Meilgaard et al., 2006), Texture Profile (Szczesniak, 1966 as cited by Lawless & Heymann, 2010; Civille & Liska, 1975, as cited by Lawless & Heymann, 2010), Flavour Profile method ® (Cairncross & Sjöstrom, 1950 cited by Lawless & Heymann, 2010; Meilgaard et al., 2006). These test methods use 8-12 trained assessors (Heymann et al., 2012; Lawless & Heymann, 2010) and comprise of a qualitative aspect that provides the descriptive terms, attributes or descriptors that define the perceived sensory parameters of the products and a quantitative aspect where these descriptors are adjudged intensity values on a 10cm or 15cm measurement scale (Meilgaard et al., 2006).

QDA® was developed to satisfy sensory experts due to the absence of statistical treatment of data obtained from Flavour profile and related methods. The QDA® is the most widely used methodology and provides in depth information on a product, however it is time consuming and expensive (Dairou & Sieffermann, 2002); and the food industry is always taking "go-no go" decisions which are time sensitive. There is a constant desire for less-time consuming methods that give rapid and accurate results (Stone & Sidel, 2004). Some adopted rapid profiling methods are Napping® (Pagès, 2005; Risvik et al., 1994; Risvik et al., 1997) and Flash Profiling (FP) (Dairou & Sieffermann, 2002) where the qualitative aspect of the products and how they are grouped in the sensory space are the considerations.

Sensory perception is a dynamic phenomenon that QDA®, Napping®, FP and other descriptive methods fail to capture. The development of temporal methodologies that are rapid and allow appreciation of sensory perception during the eating process have gained prominence (Cliff & Heymann, 1993).

2.2.3 Time-dependent (Temporal) techniques

The process of eating and drinking is continuous, as such perception of aroma, taste, flavour and texture in foods is also a dynamic process. . This implies that the perceived intensity of the sensory attributes change from moment to moment. For example chewing gum relies on timely release of flavours and taste (Ng et al. 2012).

One of the challenges in sensory evaluation is distinguishing the rapidly changing sensations that embrace the dynamic properties of products. Descriptive tests only make uni-point assessments of sensory properties and therefore provide an overall impression of the attribute at maximum intensity and not its time course of sensation hence, the full temporal encounter is not captured. The assessors 'time-average' or approximate only the peak intensity in order to provide the single intensity score that is required. Some important information may be missed due to such a single value. It is possible, in some cases for two products to have similar or even the same 'time-averaged' descriptive profiles, but vary in the order in which different flavours occur or when their highest intensities are achieved (Lawless & Heymann, 2010).

Temporal sensory evaluation of foods is a complex undertaking, but also one that is pertinent to understanding perceptions during consumption. It involves the assessment of many in-mouth sensations (olfactory, trigeminal and gustatory, as well as sound, texture, and temperature) that are not stationary but rather evolve over time. For most sensations, the perceived intensity rises and

diminishes with time (Lawless & Heymann, 2010). The terms temporal methodologies, time-dependent techniques or dynamic sensory tests are used interchangeably; and are descriptive methods too, except that the product attributes and intensities are tracked over time. They are mainly Time Intensity (TI), Temporal Dominance of Sensation (TDS), Temporal Order of Sensation (TOS) and Temporal Check All That Apply (TCATA). These tests deal with in-mouth sensations only and have seen many applications in product development and characterization, quality control, and consumer insights and marketing (Bord et al., 2019; Cadena & Bolini, 2011; Castura et al., 2016; Gomes et al., 2014; Rodrigues et al., 2014; Sokolowsky & Fischer, 2012; Zorn et al., 2014)

2.2.3.1 Time intensity (TI)

Time-Intensity (TI) method developed by Larson-Powers and Pangborn (1978), cited by Labbe et al. (2009), is a dynamic sensory method useful in tracking the changes in a specific attribute over time (Le Révérend et al., 2008).

The method was principally developed as a means of studying the persistence of tastes such as bitterness, sweetness and astringency (Cliff & Heymann, 1993). It has lately been extended to many other sensations with applications in product characterization of food categories such as beverages, wine and beers (Fritsch & Shellhammer, 2008; Gotow et al., 2015; Vazquez-Araujo et al., 2013); chocolate and chocolate products (Palazzo & Bolini, 2014; Sook Chung & Lee, 2012) and ice cream (Cadena & Bolini, 2011). The result of TI measurement is a curve showing how the reported intensity of the sensation of a specific attribute rises and falls during tasting of a product. TI method is executed only on a small number of attributes or with a limited number of products since only one attribute is assessed at a time making it relatively time consuming according to Pineau et al. (2009).

2.2.3.2 Temporal Dominance of Sensations (TDS)

Temporal Dominance of Sensations (TDS) is another dynamic sensory method developed at the "Centre Européen des Sciences du Goût" in the LIRIS lab in 1999 and was first presented at the Pangborn Symposium by Pineau, Cordelle, Imbert, Rogeaux, & Schlich in 2003 (Pineau et al. 2009). This descriptive sensory method consists of presenting to the assessor the complete list of predetermined attributes to assess which of the attributes is perceived as dominant and in some cases simultaneously allocate an intensity score to this dominant sensation in one sampling. In the course of the evaluation, when the assessor thinks that the dominant attribute has changed, either in quality or in intensity, he/she has to score the new dominant attribute, and so on, until the point of no perception (Pineau et al., 2009). Dominance may be defined as the 'most intense sensation' according to Labbe et al. (2009) or 'the sensation that catches attention (striking) at a given time, not necessarily being the most intense' (Pineau et al., 2009; Zorn et al., 2014) thus it is very necessary to explain what dominance means to the panel before they start assessment. TDS is widely applied in characterization of beverages such as coffee (Barron et al., 2012; Dinnella et al., 2013); chocolate products (Morais et al., 2014), fermented milk drinks including yoghurts with different textural properties (Esmerino et al., 2017; Bruzzone et al., 2013) and ice cream (Varela et al., 2014).

2.2.3.3 Temporal Order of Sensation (TOS)

Temporal Order of Sensation (TOS) requires assessors to identify from a simple checklist the perception of key attributes over multiple intakes or samplings of a product including the aftertaste product attributes in the order that they are perceived over the eating period (Pecore et al., 2011). The attributes that are noticed may not be the most striking or intense. Due to this method's

emphasis on order of attributes, it may be restrictive depending on the objective. However, TOS is useful for product screening and quick profiling because of its ability to assess multiple attributes at a time and appears relatively simple and quick to execute by assessors. The simplicity of this method allows the possibility of paper-based data collection (Castura et al., 2016).

Although this method has not been extensively applied, there have been reported TOS studies involving reformulations of both a savoury and a sweet food system that illustrated key perceptible differences in the impact of the flavour attributes including the aftertaste sensations relative to a control product. Simultaneous consumer testing showed that such TOS differences are essential to product acceptance (Pecore et al., 2011).

2.2.3.4 Temporal Check All That Apply (TCATA)

Temporal Check All That Apply (TCATA) developed by Compusense Research Institute, is a new addition to the temporal methods which also describes the multidimensional nature of sensory properties of food as they progress with time (Castura et al. 2016). It is an adaptation of TDS except that selection of attributes is not based on dominance but rather on whether it is present and can be deselected any time they are not perceived thus more than 1 attribute can be selected at a time (Castura et al., 2016). TCATA is an extension of Check All That Apply (CATA) method by allowing continuous selection and deselection of attributes that apply to the product overtime and thus have a similar layout like a CATA question. Assessors are allowed to check attributes whenever perceived, and to uncheck attributes whenever inapplicable. Multiple attributes can be selected concurrently, which may allow description of sensations that are perceived simultaneously. TCATA characterizes the unfolding of sensory changes the product undergoes over a time frame. According to Sanderson and Hollowood (2017), TCATA like TDS is a

relatively quick procedure to carry out and probably best suited to products where the sensory characteristics of the test product evolve over several seconds to minutes rather than longer periods of time. Application of TCATA on products including fermented dairy drinks (Esmerino et al., 2017), yoghurts (Castura et al., 2016) resulted in complete product descriptions.

2.3 FACTORS THAT INFLUENCE SENSORY TESTING

Various considerations go into the design and execution of a sensory test. These include selecting the appropriate test design, choice of venue, type of assessors, sample preparation, presentation and serving temperature among others; and these choices are greatly dependent on the sensory test objective to ensure uniform treatments and reduce chances of introducing a bias in the data collected. Lawless and Heymann (2010) describe biases in sensory perspective as tendencies in judgment in which the response is influenced in some way to be an inaccurate reflection of the actual sensory experience. Several factors must be controlled to reduce bias and obtain good quality data that is a very close reflection of the sensory properties or experience of the food (Lawless & Heymann, 2010; Meilgaard et al., 2015). Potential biases stem from factors related to the product, people, place, procedure and other psychological factors.

2.3.1 Procedure (design)

It is relevant to have a clearly defined sensory objective in order to select an appropriate test method and design (Meilgaard et al., 2015). Failure to do so could result in one misapplying a test method that measures affectivity to determine the profile of a product instead of a descriptive method and squandered time and resources. The instructions to assessors must be very clear so they understand the task. For example, in a paired comparison test to determine if there is a

difference in sweetness between two cookies, the researcher must not ask the assessors if an 'overall difference' exists rather if there is a 'difference in sweetness' between the cookies.

The sensory test design should be set up taking account of unknown sources of biases. Samples must be blind coded with random 3-digit codes and in some cases a double-blind presentation where the panel leader/test executor does not know the correspondence between the codes and the nature of the test product. Presentation of samples should be randomized to minimize biases due to order effect; and inserting time breaks and palate cleansing to minimize carryover effects (Meilgaard et al., 2015; Issanchou, 2018). The researcher should always consider whether the method is appropriately executed and determine whether there were errors introduced at any stage of the test.

2.3.2 Place (environment)

It is important to control the sensory testing environment made mainly of the preparation and testing areas. The preparation area (also called the kitchen) is any allocated space used for product preparation, handling and serving whiles the testing area is where assessors carryout the evaluation of the test products. The layout should be such that both areas are segregated from each other and assessors should not be able to see what goes on in the preparation area. The testing areas are made of a discussion area and individually partitioned booths where assessors carryout individual sensory evaluation of the products (see Figure 2.1). The sensory testing environment should have adequate and shadow-free illumination to prevent unwanted differences in appearance. It should be odorless and noise-free. The environmental temperatures in the preparation and testing areas should be regulated with the test product in mind (Meilgaard et al., 2015; O'Sullivan, 2017; Issanchou, 2018; Beeren, 2018).

Just as the atmosphere of a restaurant affects a dining experience, the setting of the sensory room can influence the assessment of a product and must be controlled for odours, noise, lighting and temperature. This ensures that the assessors are not distracted or biased by their surroundings and their assessments are solely on the product they are testing.

Figure 2.1: Sensory testing area

2.3.3 People (Assessors)

The way the assessor interact with the product, the test procedure and the environment are all possible sources of variations in the test design and therefore necessary to minimize the extraneous variables that can cause a bias in the results (Meilgaard et al., 2015). The assessor is the most important component of sensory and consumer testing and must be in optimal physiological condition when undertaking testing. Assessors are screened to determine their suitability to participate in sensory and consumer research (Lawless & Heymann, 2010, O'Sullivan, 2017). For product-oriented tests, the criteria for selection for sensory acuity is stricter as the assessors are required to be objective in their assessments. They are to have normal colour vision and screened for anosmia (inability to smell or detect odours) and ageusia (inability to taste). Consumer tests typically require users of the product category who are excited to participate. In both cases, the

people selected should not be allergic or hypersensitive to the products, be in good health free from conditions like dental problems, chronic colds and diabetes and be nonsmokers as smoking can dull the gustatory and olfactory sensations (O'Sullivan, 2017). Taste and odour perceptions have been observed to decrease with diseases such as cancers (Murtaza et al., 2017); and increasing age with major decline in sensory perceptions reported to typically occur from age 60 (Issanchou, 2018). Other physiological events such as hunger, pregnancy and menstrual cycle in women, and moods have been reported to show varying sensitivities to sensory perceptions and judgements (Meilgaard et al., 2015; Issanchou, 2018).

2.3.4 Psychological factors

Human assessments can easily be influenced by psychological factors. The researcher must ensure the chosen sensory method including the experimental design and choice of scale minimizes these biases. Stimulus error, expectation error, logical error, suggestion errors are some types of psychological errors (Meilgaard et al. 2015)

Stimulus error occurs when assessor judgement is swayed by irrevelant criteria such as the colour of the container or other characteristic of the sample and they tend to find differences when they do not exist (Issanchou, 2018; Meilgaard et al., 2015). Logical error occurs when assessors form associations between two or more characteristics of a product such as associating an intensity in flavour with an increasing intensity in colour of the product. Suggestion error occurs when other assessors influence an assessor's judgment. Expectation errors occurs when assessors obtain some information on the products they are about to evaluate. studies show how providing brand notification and other information on cheeses (Lahne et al., 2014) and mango juices (Chatterjee & Modi, 2015) increased liking scores compared to the products in the blind state.

2.3.4 Product (sample)

Product handling is critical for accurate data collection and is influenced by the preparation time and procedures, serving temperature and procedures, sample randomization and sample screening. The temperature at which samples are served can affect appearance, aroma, flavour and mouthfeel perceptions and may result in varied responses during assessments hence it is important that the serving temperature remains constant throughout the experiment to obtain comparable results (Beeren, 2018). For example, if the sample temperature is not controlled one sample could be scored differently based only on temperature. Studies have shown effects of temperature on taste sensitivity (Bajec et al., 2012; Lipscomb et al., 2016; Pramudya & Seo, 2018). For consumer or affective tests, although samples are often served at the temperature at which such products are typically consumed, there have been studies reporting the influence of serving temperatures on consumer acceptance of various beverages including milk and wine (Cliff & King, 2009; Francis et al., 2005; Pramudya & Seo, 2018; Ross & Weller, 2008). In descriptive or discriminative tests, temperatures may have to be modified to justify the fact that taste acuity has been investigated to be greatest at temperatures between 20°C and 40°C (Poste et al., 2011). When products are served too cold, perceptions of sensory attributes and detection of changes in those attributes especially aroma and flavour are low because they are perceptible as volatiles. An increase in temperature may also change the product altogether and scald the tongue. Ice cream is the product in the frozen dessert category that has received several sensory studies.

A compromise of any of these factors may introduce extraneous influences and errors and the results of the test may be misleading to the researcher (Lawless and Heymann, 2010; Meilgaard et al., 2015; Poste et al., 2011).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 MATERIALS

3.1.1 Products used:

Two types of frozen desserts were used throughout the whole study. At different stages of the study, one or both products were used and presented in different physical forms. The table below shows the products used, for which study and in which form(s).

Table 3.1: Products used in the study

Name of products	Study	Physical form in which used
1. Strawberry flavoured yoghurt in pouch	Preliminary study : Consumption style test	Frozen
2. Chocolate flavoured milk drink in pouch	i. Preliminary study : Consumption style test	
	ii. Thawing test	
	iii. Pre-training of panel	
	iv. Descriptive tests	Frozen, Slushy, Liquid
	v. Consumer test	
3. Milk chocolate beverage { 1 tablespoon cocoa powder, 2 tablespoon refined sugar, 6 tablespoon dairy milk powder and 700ml hot water (90°C)}	Dummy for warmup in for consumer test	Liquid

3.2 METHOD

3.2.1 Study design

The main study was carried out in four (4) main phases. It began with a survey to understand how Ghanaians typically consumed the frozen desserts; followed by a thawing test to identify the corresponding temperatures for the physical states identified, then descriptive assessment, and consumer acceptance of the products in the three (3) physical states. Figure 3.1 below illustrates the conceptual flow of the study. Prior to the main study, a preliminary consumer study to investigate the consumption styles and identify the type of product to use for the main study was conducted and guided the direction of the conceptual framework of the study.

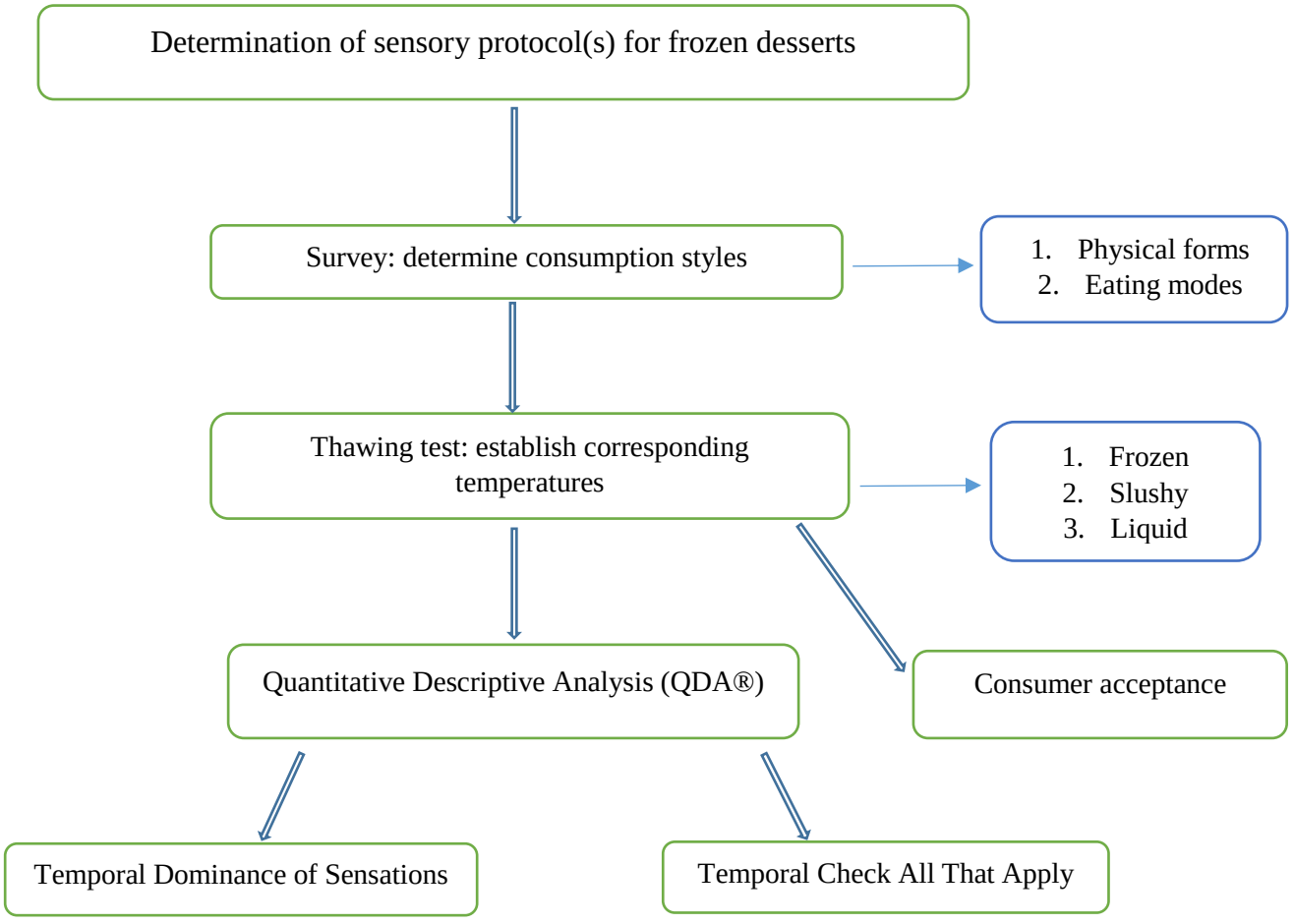

Figure 3.1: Conceptual flow diagram of the main study

Keys: Green box - Project objectives (activities) Blue box - outcome for the activity

3.2.2 Environmental control

All the sensory tests were carried out in the Sensory Evaluation Laboratory of University of Ghana. The laboratory is equipped with a preparation area, discussion area and separate tasting booths for assessors. The lab is well-lit with white LED light providing natural white light illumination and a well- ventilated atmosphere with temperature maintained at ambient ($24^{o}C \pm 2\,^{o}C$). An extractor fan is installed to remove unwanted odours from the environment. Samples were served through hatches behind a closed partition to minimize interaction and possible bias from research staff.

3.2.3 Consumption style study

A preliminary (pilot) consumer study on the consumption style was carried out to investigate how Ghanaians typically consumed frozen dairy-based desserts that come packaged in polyethylene pouches and whether they consumed these kinds of products in the same manner. Fourteen (14) participants from the University of Ghana community completed the study. Two popularly consumed sachet packaged products on the Ghanaian market; a strawberry flavoured yoghurt and a chocolate flavoured milk drink were used. The products were served as is in their original packages at -13°C ± 2°C.

Each consumer was presented with a full sachet of each product to consume as they normally would and indicate how much they liked the product at first bite and after total consumption. They were asked to also indicate the level of thawing if they thawed their product before consumption. The presentation of products was randomized. Observations of the manner in which the participants consumed each product were recorded.

Through this study the product for the main study was selected and knowledge on the physical forms and manner in which people consumed such products were established to be further investigated in the survey.

3.2.4 Assessor selection, pre-training and sample preparation

A panel of 8 members (4 males and 4 females) who had undergone screening and selection after completing triangle tests, generation of terms, taste and odour identification, ranking tests; and have gone on to participate in at least 4 descriptive tests of products including dairy related ones were selected and pre-trained on temporal test methods. The frozen chocolate flavoured milk drink served in the frozen, slushy and liquid forms was used in the pre-training exercise.

The pre-training exercise included training on the concept of temporal tests methods and how the trained panel should use the software and computer in the evaluations. The frozen state was used in this exercise. This exercise provided an avenue to obtain a sound test protocol and ensure trained panel understanding as well as product handling techniques.

Six days were dedicated to familiarizing the assessors with the use of the computer system for TCATA and TDS. The panel met 3 hours per day 3 times a week.

The samples were prepared as follows;

i. Frozen form

The tail ends of the product in the frozen form were cut to obtain a rectangular shape before cutting it into the used sizes. The sizes varied per test method. This is reported under the specific methods. The product presented in the frozen state was served at -10°C ± 2°C and maintained in the freezer.

ii. Slushy form

The product was thawed from -18°C to -8°C in its primary package. The tail ends of the product was cut off to obtain the rectangular shape and then cut into the needed sizes according to the test method. The sample was served at -4°C ± 2°C. Temperature balance was maintained by placing products in the fridge and in the freezer where necessary.

iii. Liquid form

The product was thawed from -18°C to 8°C in its primary package. The sample was refrigerated and served at 4°C ± 2°C.

3.2.5 Thawing test

The melting time of the chocolate flavoured dessert in the frozen state was observed. About 100g of the unwrapped test product was placed in a High-density polyethylene (HDPE) container uncovered. A thermometer was inserted in different parts of the product to measure the temperatures as the product changed in physical state. Thawing of the frozen sample was observed from -18°C through to 6°C with time recordings made with every 1°C drop using a timer. Measurements were taken from specific parts of the sample to determine the mean drop in temperature. Thawing tests were carried out at environmental temperatures of 20°C, 26°and 32°C to mimic the ambient temperature range in the sensory laboratory setting and typical hot sunny day in Ghana. The tests were carried out in triplicate for each environmental temperature. Through the thawing tests, the corresponding temperatures to the physical states of the test product were determined.

3.2.6 Consumer tests

3.2.6.1 Survey

To understand how Ghanaians conventionally consume and like the frozen dairy-based desserts packaged in plastic pouches, a total number of 384 Ghanaians currently living in Ghana were targeted to complete an online-administered survey questionnaire using Compusense Cloud® (Compusense 5, Guelph, Ontario, Canada). The survey sought to reveal the following;

i. How Ghanaian consumers normally consume frozen desserts particularly those packaged in a sachets
ii. The form in which they like to consume such products and how they achieve those forms
iii. How long it takes for them to consume such products
iv. Whether the physical states and temperatures of the products influence their liking

3.2.6.2 Consumer acceptance test

One hundred and twenty (120) willing Ghanaian consumers of frozen desserts who are not allergic to the test sample were targeted from University of Ghana main campus. The sensory test was carried out in the Sensory Evaluation Laboratory of the University of Ghana and the participants signed a consent form prior to the exercise. The test was conducted on the flavoured milk chocolate product in the frozen, slushy and liquid states shown in section 3.2.4. A dummy sample which is unrelated to the products but a chocolate-milk beverage was first presented to the participants as warm-up before actual tasting of the test samples. This was done to set the tone for the evaluation and minimize the bias that may be caused by first order effect. The dummy sample was served at 4 °C ± 2°C.

Participants were presented with the test samples in a randomized monadic order and asked to indicate their overall liking for each sample on a 9-point hedonic scale at initial consumption (first bite for frozen and slushy form or intake for liquid form), mid-way of consumption and at the end of consumption.

Sample presentation was in a balanced randomized block design according to the Williams' Latin Squares (Williams, 1946) and presented one after the other to the participants. A predetermined list of attributes obtained from the QDA test (see Appendix 7) was also presented as a check-all-that-apply (CATA) question for the participants to select the attributes that influenced their liking or disliking for the test samples, similar to the use of CATA in consumer studies by Jaeger et al. (2015). Water was presented to the participants to cleanse their palate and 30-second time breaks were enforced between sample tastings. The data was collected with Compusense Cloud® (Compusense 5, Guelph, Ontario, Canada).

3.2.7 Descriptive tests

The chocolate flavoured milk drink, same as what was used in the consumer study, was used for all the 3 descriptive test protocols. The samples were prepared and handled in the same way as outlined in Section 3.2.4.

3.2.7.1 Quantitative Descriptive Analysis (QDA®)

The sensory profile of the frozen dessert in the 3 different states were determined using the QDA® method (Stone et al., 1974). Eight trained sensory assessors with an average of 1 year experience in sensory profiling of foods using QDA® method were used in this study. The amount of sample served each time was 40g in blind coded 80ml transparent disposable plastic cups and covered with lids. The assessors generated terms that described the sensations elicited for the sensory

modalities; appearance, aroma, flavour, mouth feel and aftertaste/after effects. Terms were compiled and streamlined using a check all that apply (CATA) method where the assessor confirmed the attributes that described the samples. This activity is unique to the Sensory Evaluation Lab. Consensus, definitions and anchors were established for the descriptor list. Scale training to establish the ranges of the intensities of each attribute per sample and trial evaluations in duplicate were also carried out. Three days were used to achieve these training activities due to the panel's experience in QDA®. Final evaluation of the sample set was carried out in triplicate on a 10cm line scale with 3 samples evaluated per replicate. Samples were randomized within sample sets and sample sets randomized across replicates. A session was 3 hours long. The final evaluation was carried out in a session. Forced breaks between each sample tasting was set at 30 seconds and 10 minutes forced break between replicate tastings of sample sets were enforced. Throughout training and final evaluation, samples were presented in a random monadic order and balance was maintained using the Williams' Latin Squares (Williams, 1949). Approximately 10g of the frozen sample was provided as a warm-up sample before every evaluation of the 3 samples. This was done to condition the mouth's temperature of the assessors. Water was provided to the assessors as palate cleansers.

3.2.7.2 Temporal Check All That Apply (TCATA)

Prior to the actual test involving the test samples, the panel received pre-training on the test method to explain the protocols and establish sample quantities and total duration of test.

The predetermined attribute list from the QDA® were used in this test method. The list comprised of flavour, mouth feel and aftertaste/aftereffect descriptors. Assessors were presented with 10g of sample. Samples were randomized using Williams Latin Squares (Williams, 1949) and presented

to assessors in a monadic order. The TCATA computerized system shows the assessor the entire list of attributes on a computer screen (Figure 3.2). For every evaluation exercise, the presentation of the lists on the screen were randomized for assessors but remained the same throughout that evaluation to control order effects and make it easier to learn the positions of the attributes. This improved the efficiency of the assessors in attribute selections. Approximately 10g of the frozen sample was also provided as a warm-up sample. The assessors were instructed to place the 10g of sample in their mouth and simultaneously click the start button of the timer. They were asked to keep the samples in their mouths and select all the attributes they perceived as the samples melted in their mouths. Whenever a new attribute was perceived a selection was made. Attributes selected remained highlighted on the screen and were unselected by assessors when they no longer perceived them. During each tasting, the computer records for each selection, the time elapsed since the start button was clicked and the name of the attribute selected.

Assessors stopped the timer when the perception ended. The test was set to run for 400s. The frozen and slushy samples were swallowed after they were completely melted in the mouth and then evaluated for their aftertaste sensations. The liquid sample was swallowed after holding in the mouth for 20s and evaluated for aftertaste sensations.

Final evaluation was carried out in triplicate and a 30 second time break was enforced between sample tastings and a 10 minutes break between replicates. Samples were randomized within sample sets and sample sets randomized across replicates. The panel used 2 days for training, 1 day for trial evaluation in duplicate and 1 day (a session) to complete the final evaluation in 3 replicates.

3.2.7.3 Temporal Dominance of Sensation (TDS) with intensity scoring

Prior to the actual testing of the samples, the panel received pre-training on the test method using a similar product to explain the protocols and establish sample quantities and total duration of test. Evaluation of the products followed the protocol described by Pineau et al. (2009) below and from the pre-training to the actual training sessions, a dominant attribute was defined as 'the attribute associated to the sensation catching the attention at a given time'. It was agreed as 'the new sensation popping up at a given time' (Pineau et al., 2009). It was explained to the panel that the dominant attribute was not necessarily the one with the highest intensity.

The predetermined flavour, mouthfeel and aftertaste effect descriptors from the QDA® were used in the actual test method. Samples were randomized using Williams Latin Squares (Williams, 1949) and presented to assessors one after the other. Assessors were presented with 10g of sample. The TDS computerized system using Compusense Cloud® (Compusense 5, Guelph, Ontario, Canada) showed the assessor the complete list of attributes on a computer screen (Figure 3.2). To reduce the bias caused by order effect of the attributes, the order of the attributes was randomized using the Williams Latin Squares (Williams, 1949) and differed for each assessor. To facilitate the efficiency and adjustment of the terms by assessors, the attribute order remained the same for each assessor. Also approximately 10g of the frozen sample was provided as a warm-up sample.

The assessors were instructed to put the 10g of sample in their mouth and simultaneously pressed the start button of the timer. The assessors were then asked to track the evolution of attributes as the samples melted in their mouths by selecting the dominant attribute. Whenever a new attribute came up as dominant that attribute was selected. Only one attribute was selected at a time. Assessors stopped the timer when perception ended. The duration of the test was set at 400s. The

frozen and slushy samples were swallowed after they were completely melted in the mouth and then evaluated for their aftertaste sensations. The liquid sample was swallowed after 20s and evaluated for aftertaste sensations. During each tasting, the computer records for each selection the time elapsed since the start button was clicked and the name of the chosen attribute.

Although the idea was to simultaneously scale the intensity of the dominant attribute whenever the selection was made as used by Pineau et al. (2009) with the FIZZ Software Version 2.20E (Biosystemes, Couternon, France), the Compusense Cloud® software used in this study did not have that function. Hence, an improvised temporal line scale (10 cm in length) was used to record intensities at specific times when the dominant attribute was most intense. To complete scoring on the improvised scale, assessors were presented a different set of 10g sample (Figure 3.3) after completing the TDS selections and instructed to click the start button as soon as they put the sample in their mouth. This time they will score only intensities of the sample in order of dominance. The line scales for the attributes were not randomized. During each tasting, the computer records for each scoring the time elapsed since the start button was clicked, the name of the attribute selected and the intensity scored for the attribute.

Final evaluations were carried out in triplicate. Samples were randomized within sample sets and sample sets randomized across replicates. A 30 second time break was enforced between sample tastings and a 10 minutes break between replicates. Water was used as a palate cleanser.

Figure 3.2: Outlook of attribute presentation for TDS and TCATA on the computer

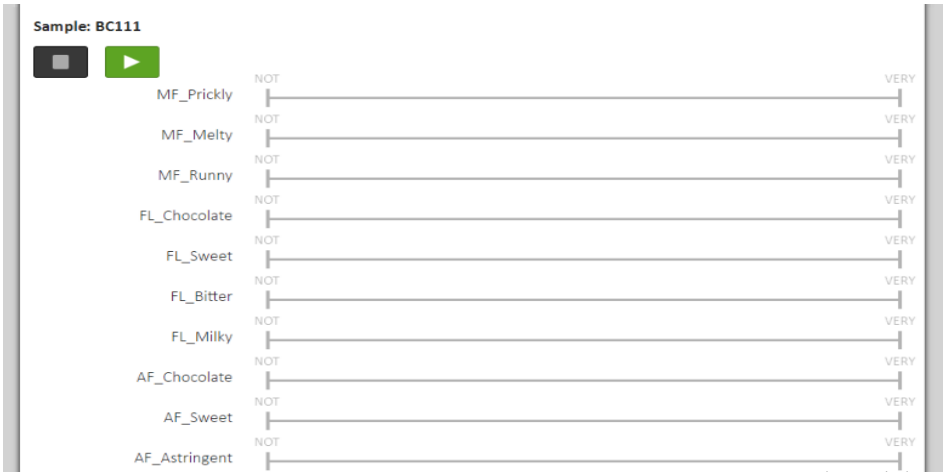

Figure 3.3: Presentation of temporal line scale for TDS

Training including trial evaluation on the actual test samples took 5 days (15 hours). Trial evaluation was conducted in duplicate to monitor panel performance before proceeding to final evaluation, which was completed in a day (3 hours).

3.3 DATA & STATISTICAL ANALYSIS

3.3.1 Consumer tests

Counts and frequencies were used to summarize the data obtained from the surveys. Two – way analysis of variance (ANOVA) was performed on consumer acceptance data treating the assessors and samples as random and fixed factors respectively. Tukey's HSD post hoc analysis at $\alpha=0.05$ was carried to identify where product differences were. Check all that apply (CATA) scores were used to explain liking and dislike for the products evaluated.

3.3.2 QDA®

A 2 – way analysis of variance (ANOVA) was performed on product means with assessors as random factor and samples and replicate as fixed factors to determine which attributes discriminated between products. Subsequently Tukey's HSD post hoc analysis at $\alpha=0.05$ was performed to identify product differences. Panel performance analysis was also carried out before final evaluation to assess panel performance in terms of repeatability, discrimination and agreement. Pearson principal component analysis was performed on mean product attribute scores to provide a 2 – D multivariate graphical outlook of the products in the sensory space based on the first 2 principal components.

3.4.3 TDS

For each point of time, the proportion of runs (subject x replication) for which the given attribute was evaluated as dominant was calculated. TDS curves for each state were constructed with the panel dominance rate (proportions) calculated for each attribute per state and at each point in time, as described by Pineau et al. (2009) without smoothing or standardization. The end of the curve represents the time at which perception ends. Chance and significant limits were plotted alongside

the curves to indicate selections of dominant attributes that were based on chance and those that were significant (Varela et al., 2014). Chance limit/level (P_0) is defined as the dominant rate that an attribute can acquire by chance, taking into account all attributes evaluated. It is the inverse of the total number of attributes. Significant limit/level (P_s) is defined as the minimum value of the dominance rate that an attribute must acquire to be significantly greater than P_0. It was calculated by using the confidence intervals based on binomial distribution (Pineau et al. 2009; Pineau & Schilch, 2015). TDS curve differences were calculated considering 2 products at a time to show the significant product differences using equation defined in (3) according to Pineau and Schilch (2015) and plotted only when significantly different from zero. Mean intensity scores for each dominant attribute per product were also calculated and analysed like the QDA® data as suggested by Pineau et al. (2009) and Ng et al. (2012).

Chance limit (P_0) = 1/ number of attributes (n) **Equation 3. 1**

$$\text{Significant limit } (P_s) = P_0 + 1.64 \sqrt{\frac{P_0 (1- P_0)}{n}} \quad \textbf{Equation 3. 2}$$

$$P_{diff,\,t} = 1.96 \sqrt{\left\{ \left(\frac{1}{n_1} + \frac{1}{n_2}\right) P_{avg,\,t} (1-P_{avg,\,t}) \right\}} \quad \textbf{Equation 3. 3}$$

$$\text{Where } P_{avg,\,t} = \frac{P_{1,t} n_1 + P_{2,t} n_2}{n_1+n_2} \quad \textbf{Equation 3. 4}$$

n_1 = number of Judgements (Assessors x replicates) for sample 1

n_2 = number of Judgements (Assessors x replicates) for sample 2

$P_{1,t}$ = Dominance rate of sample 1 at time t

$P_{2,t}$ = Dominance rate of sample 2 at time t

$$\text{TDS Mean Score} = \left(\sum_{\text{Scoring}} \text{Intensity} \times \text{Duration}\right) \Big/ \left(\sum_{\text{Scoring}} \text{Duration}\right) \quad (4)$$

3.3.4 TCATA

Differences in TCATA profiles were considered two products at a time and were achieved by taking the difference in proportions of TCATA citations for each of the attributes at each of the time points.

3.4 ETHICAL ASSESSMENT AND CONSENT

Participants were briefed on the study to enable them make an informed decision before taking part in any of the activities. Those who agreed to participate had to sign consent forms and they were at liberty to withdraw from the study at any time.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 PRELIMINARY STUDY ON CONSUMPTION STYLE

4.1.1 Demographics of participants

To determine if consumers consume two kinds of polyethylene-packaged frozen dairy-based products in the same way, 14 consumers completed the pilot test. The results are shown below in tables and graphs and statistical significance was set at 95% confidence level ($p \leq 0.005$).

Table 4.1: Consumer demographics

Category	Frequency (%) (N=14)
Gender	
Male	7 (50)
Female	7 (50)
Age group	
18-24	7 (50)
25-34	6 (43)
35-44	1 (7)

Equal number of males and females completed the test. The participants' age range was 18 to 34 years (Table 4.1).

4.1.2 Consumption style of participants

It was observed that 9 of the participants consumed the two frozen products in the frozen state whereas the other 5 consumed both products thawed to different levels (Table 4.2).

Table 4.2: Observation of participants' consumption style of frozen desserts

Physical state	Number of respondents (N=14)
Rock hard	9
Unaided/self-thaw (100% liquid)	1
20% liquid	2
80% liquid	1
100% liquid	1

One of the participants thawed the products unaided by leaving it to sit whilst the other 4 force-thawed the products by placing them in a bowl of tap water. For the participants who applied force thawing, 2 indicated that they thawed both products to about 20% liquid before consumption and another participant indicated thawing to about 80% liquid. One of the participants force-thawed the products to complete liquid before consumption. The total duration for consumption of each product was on average 30 minutes.

4.1.3 Liking scores during consumption experience

Figure 4.1 shows no significant difference in the liking scores between the two desserts at first tasting, after complete consumption and the overall experience. The frozen chocolate flavoured drink and frozen yoghurt were liked the same way at every stage.

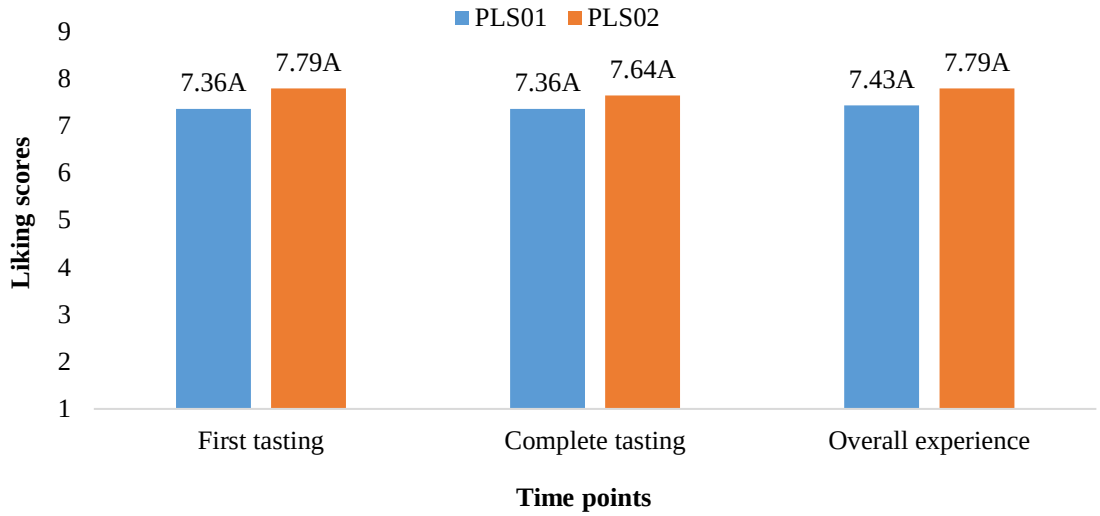

Figure 4.1: Consumer mean liking scores of the products at each time-point.

PLS01: Frozen chocolate flavoured milk drink PLS02: Frozen strawberry flavoured yoghurt

Same alphabet denotes no statistical significance at 95% confidence level

There was no significant difference in the liking scores for both frozen products throughout the consumption experience (Figure 4.3).

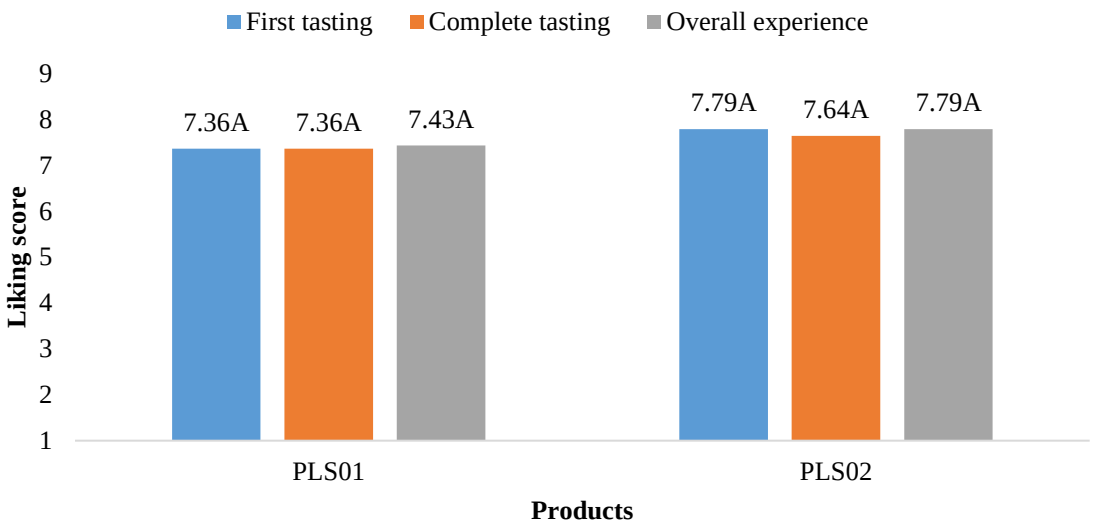

Figure 4.2: Mean liking scores of each product across time-points

PLS01: Frozen chocolate flavoured milk drink PLS02: Frozen strawberry flavoured yoghurt

Same alphabet denoted no statistical significance at 95% confidence level

Lakkakula *et al.* (2010) and Keller (2014) reported that liking scores tend to increase with continuous consumption of a product, however no statistically significant difference was observed in this pilot study. It is possible that the total number of participants was not adequate to expose true differences. This however, is of no consequence as the most relevant purpose for this test was to identify the techniques consumers use when they consume such sachet-packaged frozen desserts, if both products are consumed differently and which product to choose for the main study.

4.2 SURVEY ON CONSUMPTION STYLE OF FROZEN DESSERTS

The consumption style of frozen dairy-based desserts packaged in polyethylene pouches among Ghanaians was quantified from an online survey. Out of 361 respondents, 263 Ghanaian consumers of this product category completed the survey.

4.2.1. Demographics of participants

Two hundred and sixty-three (263) Ghanaians of diverse ethnicity, age group and living in different parts of the country completed the survey questionnaire as shown in Table 4.3. The respondents comprised of 54% females and 46% males. They were mainly Akans (46.8%), Ewes (25.1%) and Ga/Adangbe (16.3%) with an age range of 18-34 years. All of the respondents had been to school and were either employed (46.7%) or schooling at the time of the survey (46.4%). A small minority were unemployed and a stay at home parent (6.8%).

Table 4.3: Descriptive statistics for survey demographics

Category	Frequency (%) (N=263)
Gender	
Female	142 (54)
Male	121 (46)
Ethnicity	
Akan	123 (46.8)
Ewe	66 (25.1)
Ga/ Adangbe	43 (16.3)
Guan	5 (1.9)
Northerner	22 (8.4)
Other	4 (1.5)
Age	
18-24	108 (41.1)
25-34	138 (52.5)
35-44	12 (4.6)
45-54	4 (1.5)
55-64	1 (0.4)
Highest level of education	
Never been to school	0 (0)
Primary	1 (0.4)
Middle school/Junior high	3 (1.1)
Secondary/Senior high	16 (6.1)

Tertiary	239 (90.8)
Other	4 (1.5)
Occupation	
Student	122 (46.4)
Self-employed	26 (9.9)
Stay at home parent	5 (1.9)
Civil servant	23 (8.7)
Health worker	18 (6.8)
Professional	44 (16.7)
Unemployed	13 (4.9)
Other	12 (4.6)

4.2.2 Consumption patterns for frozen desserts

Majority of the respondents (57.9%) consume sachet packaged frozen desserts every day (11%) or at least once a week (47.9%) as shown in Figure 4.3.

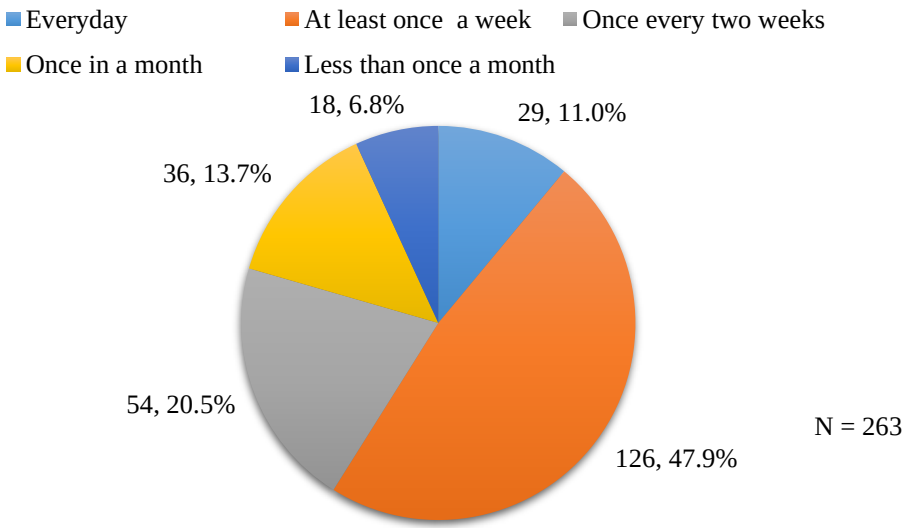

Figure 4.3: Consumption frequency of sachet packaged frozen desserts by Ghanaians

The respondents mainly consumed sachet packaged frozen desserts in the slushy (semi-solid) (62.4%) or hard (34.2%) forms and 3% of the respondents consume the dessert in the liquid state as shown in Figure 4.4.

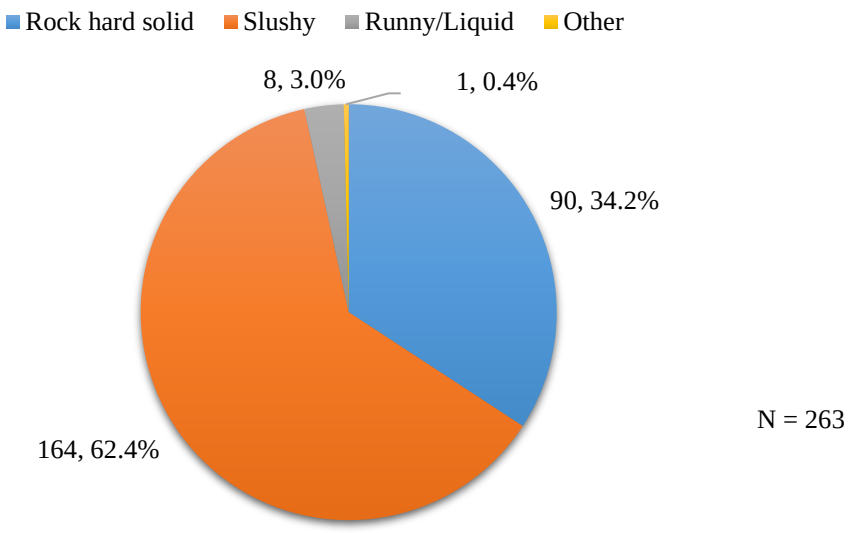

Figure 4.4: Physical states in which Ghanaians typically consume sachet packaged frozen desserts

From Figure 4.5, none of the respondents pours the content into a cup or bowl to scoop or drink and less than 5% of the respondents consume the product in the liquid state. Majority of the respondents start consuming these types of desserts while still hard using different means to consume the product. Most (almost 40%) will take bites while it is still hard, about 1/3 will crush it before taking bites. A little over 20% will suck the juices out of it. This is likely to affect the evolution of flavour, which will diminish as the juice is drawn out, and all that is left is ice.

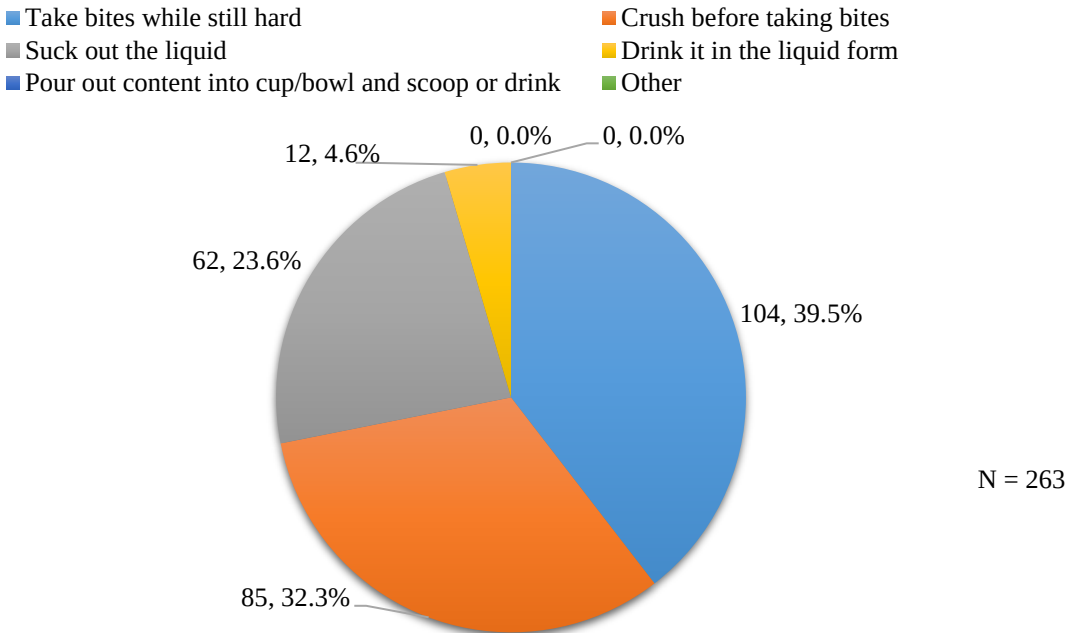

Figure 4.5: The way Ghanaians consume frozen desserts packaged in polyethylene pouches.

From Figure 4.6, majority of the respondents (66.9%) indicated that if they did not want to consume the sachet-packaged dessert in the frozen state they left it to melt to the desired texture before consuming it. Those in the 'other' category mentioned squeezing or compressing the product with fingers to make it softer.

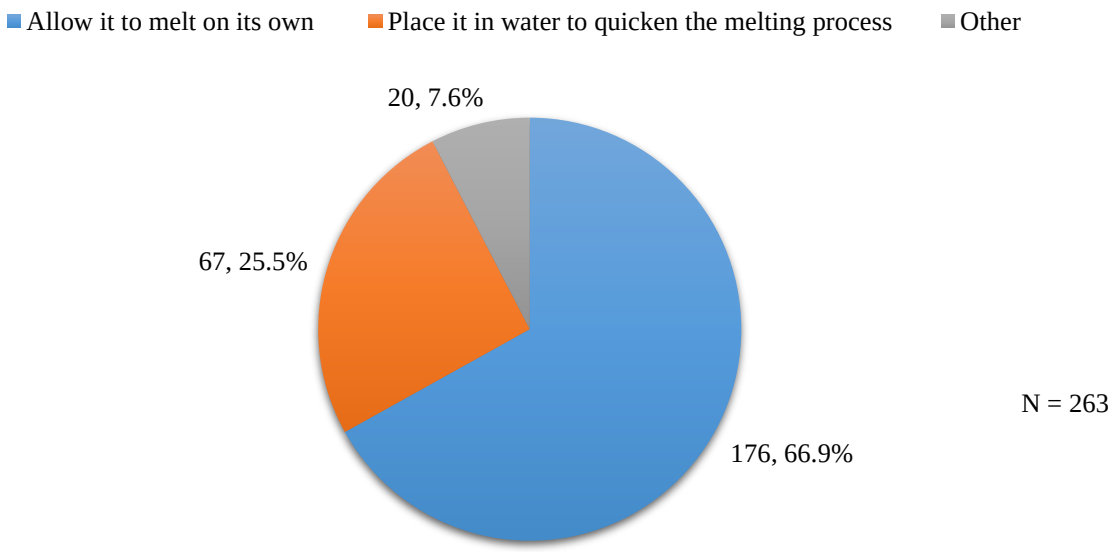

Figure 4.6: The way Ghanaians thaw polyethylene packaged frozen desserts

Almost 50% of the respondents will use between 5-10 minutes to complete consumption (Figure 4.7). Overall, it takes a typical consumer under 15 minutes to consume completely a full sachet of desserts in the frozen state, which is a net volume of about 145ml.

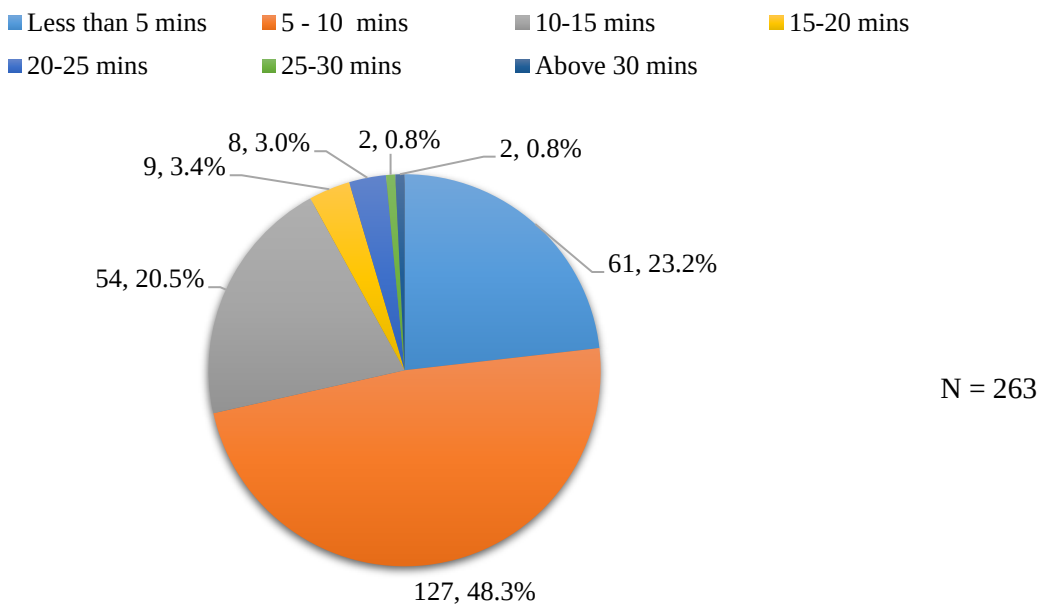

Figure 4.7: Average duration for the consumption of a polyethylene packaged frozen dessert

Responses from Table 4.4 shows that the physical state as well as the temperature of the desserts does influence the consumers' liking for these products. This assertion was confirmed in the next section of this study.

Table 4.4: Consumer responses on effect of temperature and state on liking of frozen product

	Frequency (%) responses (N= 263)				
	Not at all	Not really	Neutral	Somewhat	Very much
The physical state of your frozen dessert product influences how much you like it	7 (2.7)	36 (13.7)	37 (14.1)	82 (31.2)	101 (38.4)
The temperature of your frozen product influence how much you like it	5 (1.9)	34 (12.9)	34 (12.9)	74 (28.1)	116 (44.1)
The physical state together with the temperature of your frozen product influences how much you like it	4 (1.5)	25 (9.5)	33 (12.5)	83 (31.6)	118 (44.9)

4.3 IDENTIFYING THE POINT DURING CONSUMPTION THAT CONSUMER LIKING IS THE HIGHEST

Eighty-four (84) Ghanaian participants from the University of Ghana campus completed the consumer acceptance test. As part of the tasting exercise, the participants answered questions on the state that they enjoyed sachet packaged frozen desserts and their consumption patterns.

4.3.1: Demographics of participants

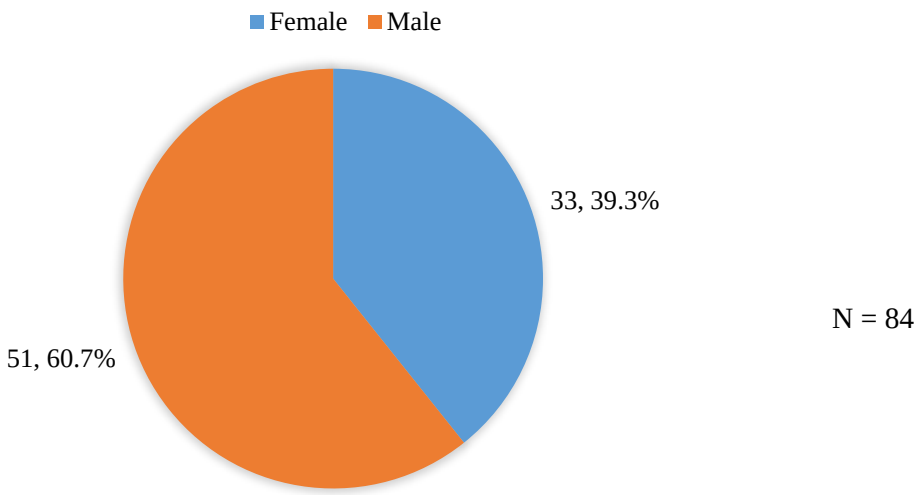

Figure 4.8: Gender distribution of participants

Fifty-one males (51) and thirty-three (33) females completed the consumer acceptance test (Figure 4.8).

The participants were largely in the age range 18 – 34 years (Figure 4.9) and mostly consumed frozen desserts once in a week (Figure 4.10).

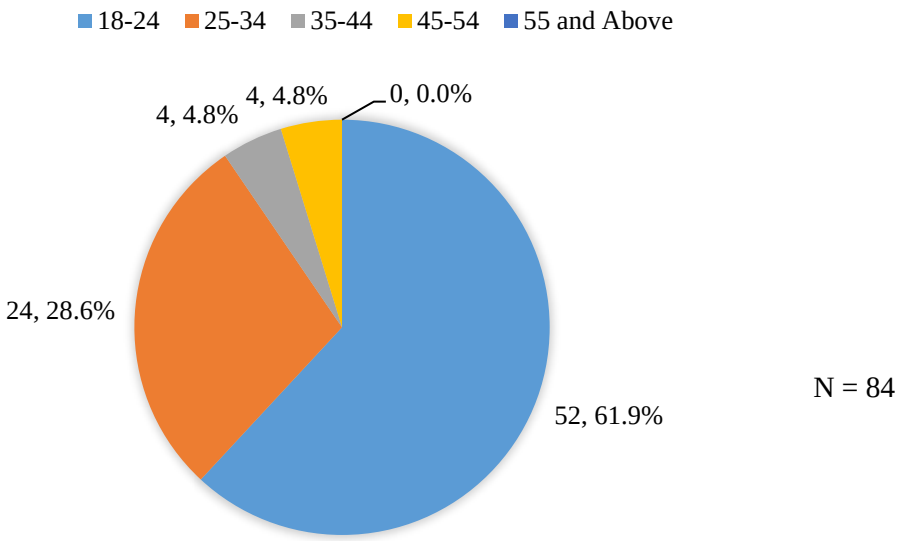

Figure 4.9: Age distribution of participants

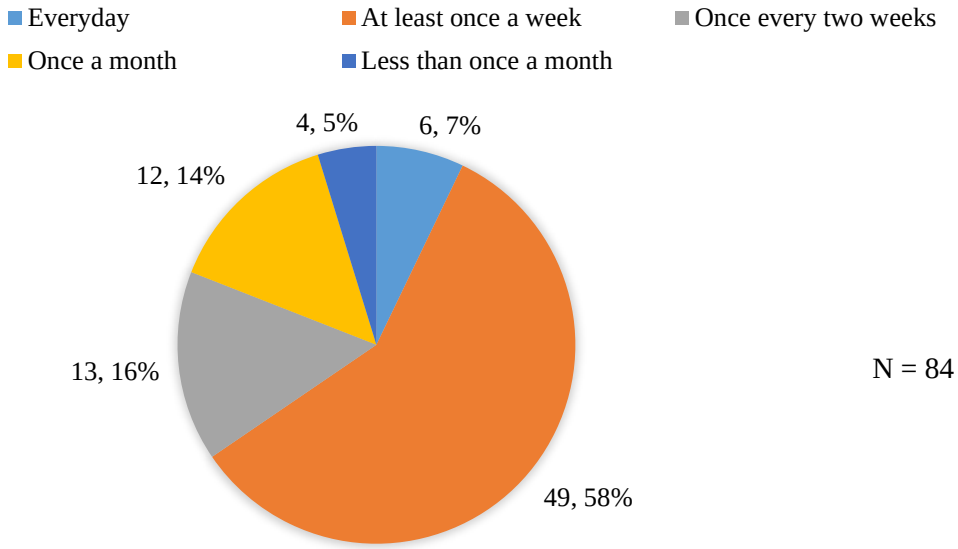

Figure 4.10: Participants' consumption frequency of frozen desserts

From Figure 4.11, most of the participants indicated that they enjoyed sachet packaged frozen desserts in the slightly melted state also referred to as the slushy state. Very few of the participants (17%) indicated that they consumed the product in the liquid state.

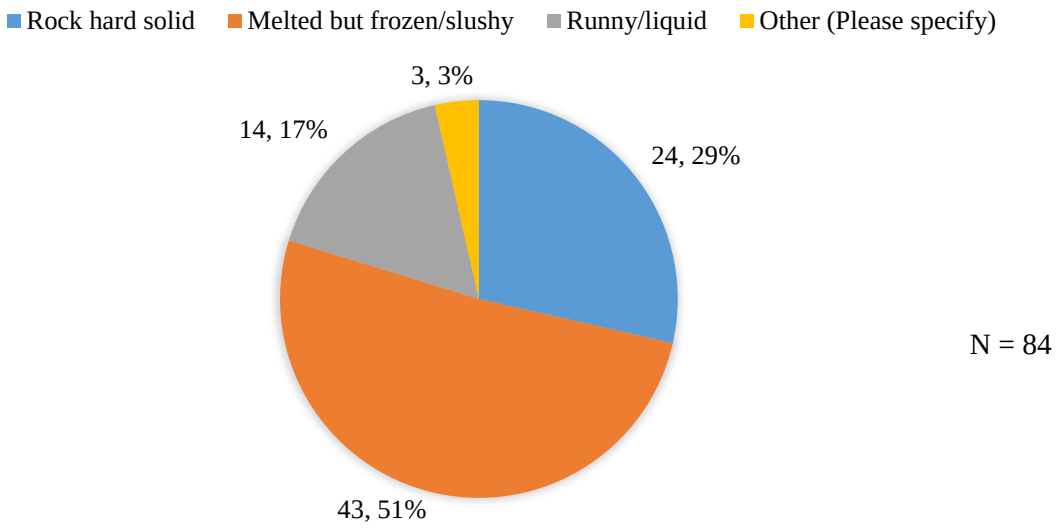

Figure 4.11: The state that the participants typically enjoy sachet packaged frozen desserts.

The participants indicated how much they liked or disliked the chocolate flavoured dessert in the different physical states throughout the consumption experience.

4.3.2: Mean liking scores during consumption experience

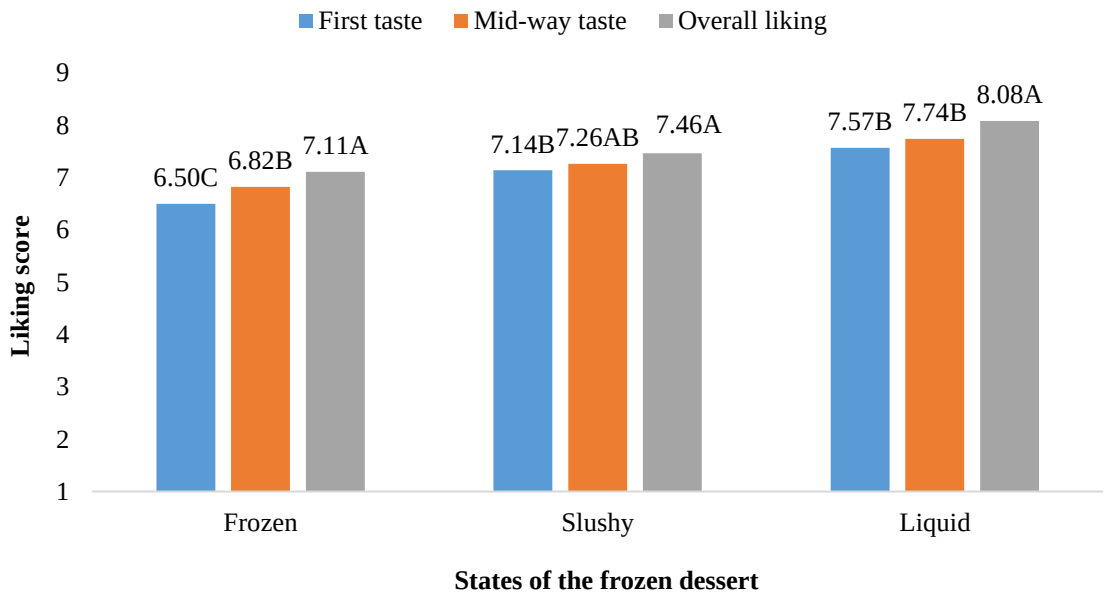

Figure 4.12: Mean overall liking scores of the states of the dessert across time-points

Same alphabet denoted no statistical significance at 95% confidence level

From Figure 4.12, the liking scores differed throughout the time-points of consumption. Liking of each state increased at the end of consumption. Consumption at first (6.50) and mid-way (6.82) taste only differed for frozen state. Increase in overall acceptability of the samples as consumption progresses has been reported to be due to repeated exposure of the products to the consumers (Lakkakula et al., 2010; Keller, 2014).

Figure 4.13 shows a statistical significant difference in the mean liking scores among the states at first taste, mid-way and overall liking after complete consumption.

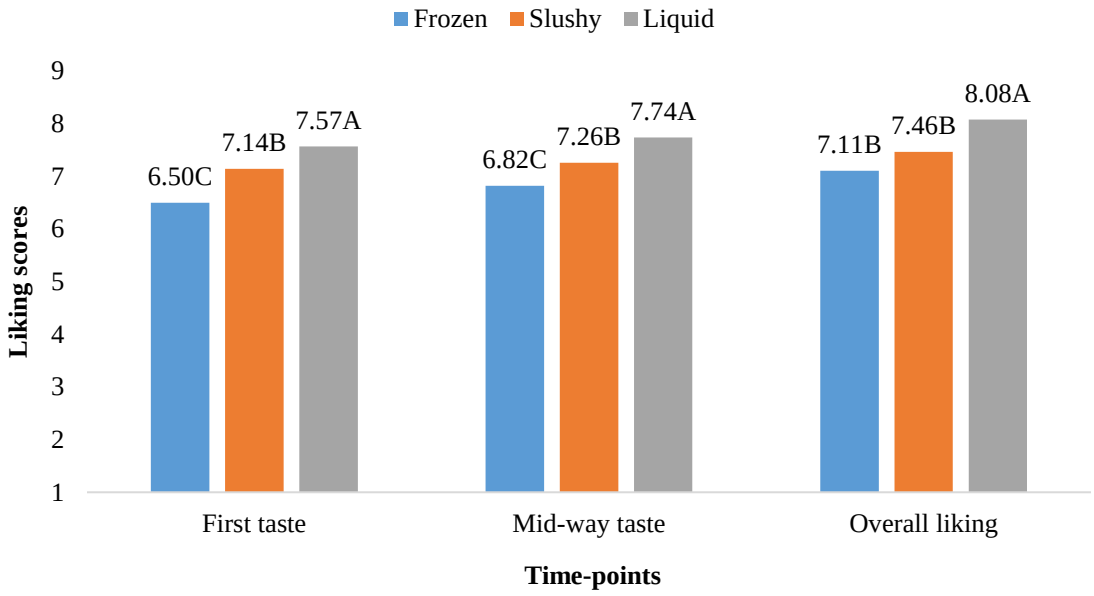

Figure 4.13: Mean liking scores among the states at different time points

Same alphabet denoted no statistical significance at 95% confidence level

At first taste and mid-way, the frozen state was the least liked but did not differ significantly from the slushy state at the end of consumption. The liquid state was liked the most at every time-point. The liking scores observed do not however corroborate with consumers' indication that they enjoyed this kind of frozen desserts in the slushy form in the previous enquiries made in this study and the survey. Sachet packaged frozen desserts are meant to be consumed on the go. The contradiction observed may be due to most Ghanaian consumers only thawing the product to the slushy state and therefore may not have experienced the product in the liquid state. It is also probable that the consumers may have considered the 3 physical states as different products although they were given prior information that it was a frozen dessert presented in different

physical states, and therefore regarded the liquid state as a beverage rather than a liquid phase of a frozen dessert.

The heightened perception of sweetness, milky and chocolate flavour in the liquid state may have influenced consumer liking as taste has been reported as a great influence on consumer liking of a product (Colonna et al., 2011; Hernandez-Carrion et al., 2014). This also implies that the dessert in its liquid state makes for a good beverage. The differences in the liking scores among the 3 states of the frozen desserts supports trends and studies that confirmed that temperature affects consumer acceptance of food (Ross & Weller, 2008). There has not been any study on frozen desserts served at varying temperatures, however, several consumer studies on formulated ice creams and other frozen desserts served at the same temperatures showed no significant difference in overall acceptability (Rolon et al., 2011; Hashim & Shamsi, 2016)

Reasons indicated by most of the consumers for liking the samples were based on taste as shown in Figure 4.14.

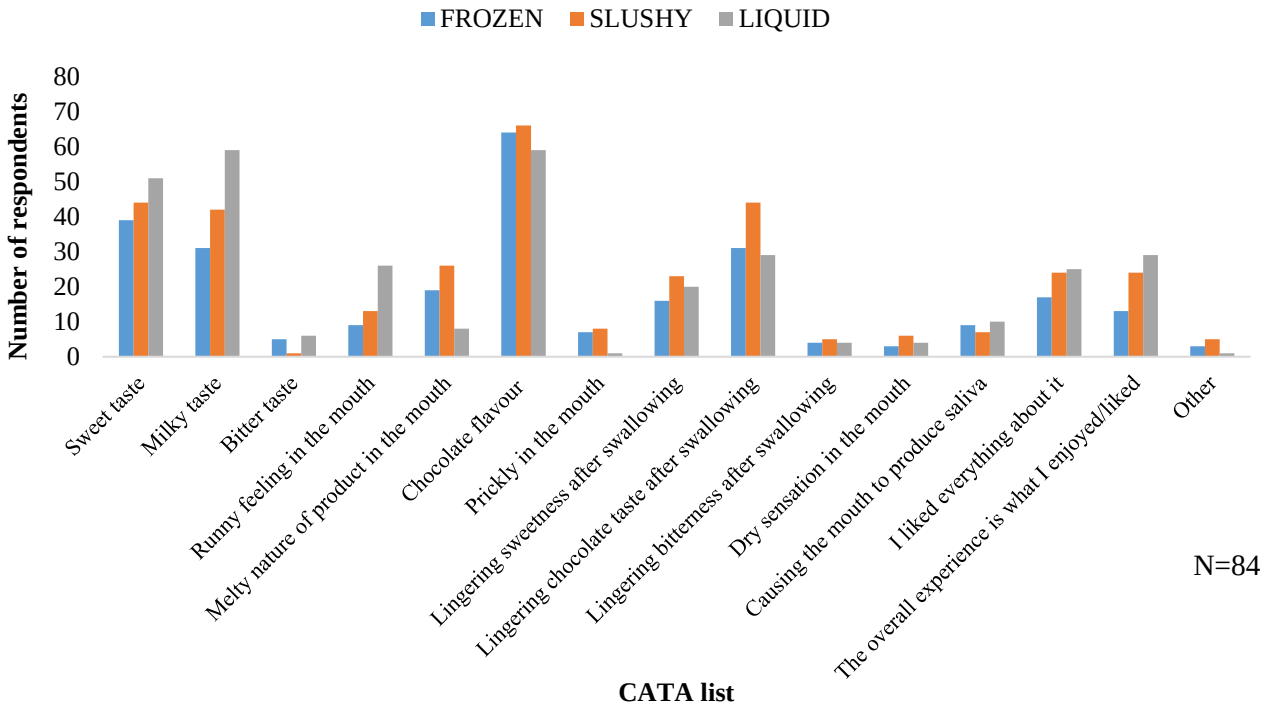

Figure 4.14: Check-All-That-Apply responses on comments for liking

Several studies have shown that consumers often rank taste as the most important factor in their choice and acceptability of foods (Colonna et al., 2011; Hernandez-Carrion et al., 2014; Honkanen & Frewer, 2009; Kraus, 2015). The frozen state was mainly liked for its sweet taste and chocolate flavour. Apart from the sweet taste and chocolate flavour, the slushy state was also liked because of its milky taste and lingering chocolate taste. The liquid state was liked because of its sweetness, milky and chocolate flavours. Apart from the influence of temperature, the physical state and texture also affects the perception of taste and flavour notes. Products with increasing viscosity have been found to decrease perception of flavour. The dessert at the different physical states possessed different surface areas and textures. The liquid state enhanced detection of the flavours by the taste buds more (Pohjanheimo, 2010).

Fewer people commented on why they disliked the frozen product at the different states as shown in Figure 4.15.

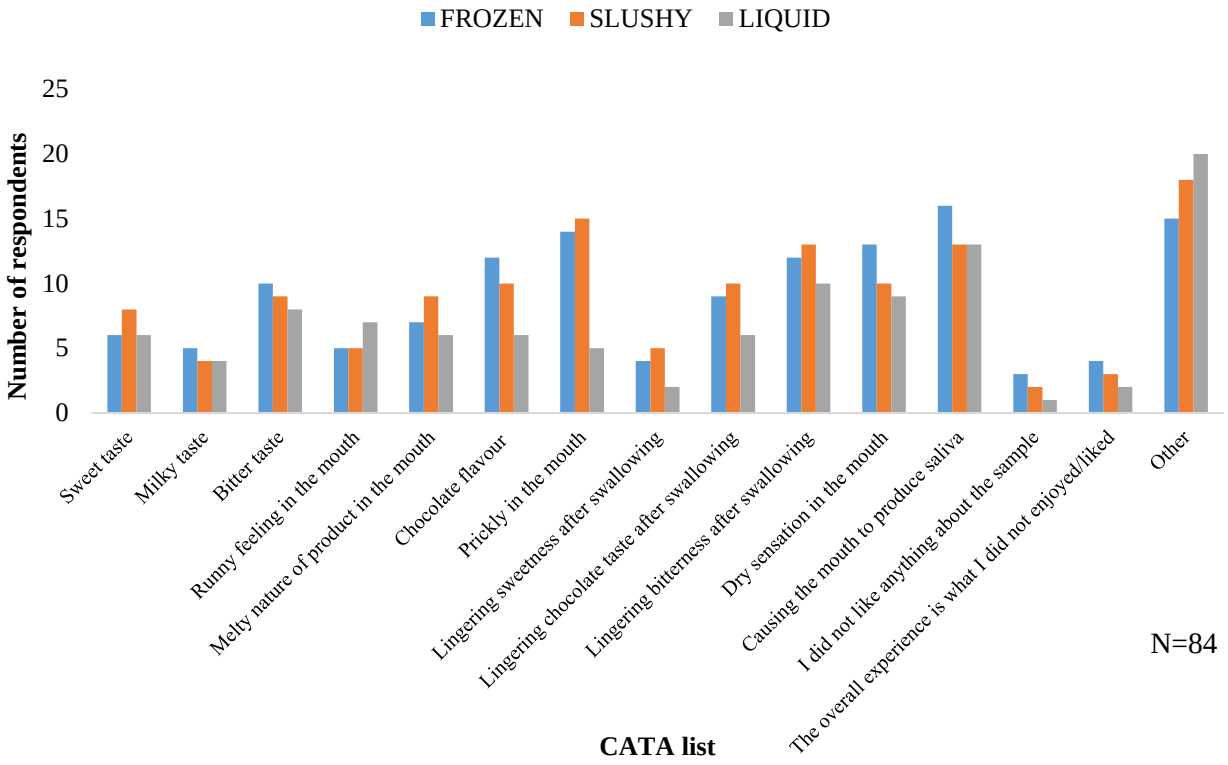

Figure 4.15: Check-All-That-Apply responses on comments for dislike

The frozen and slushy states were disliked for the prickly sensation and lingering bitterness after the products were swallowed. Those who commented 'Other' indicated that the frozen state was 'hard', 'too cold', 'tasteless' 'bitter' and 'hurt the gum'. The liquid state was described as 'too sweet' by a few others.

4.4 ESTABLISHING THE TEMPERATURES THAT CORRESPOND WITH THE PRODUCT FORMS

The frozen dessert achieved the liquid state at a faster rate (under 1 hour) at a higher temperature (32°C ± 2°C) compared to the other temperatures as seen in Figure 4.16. From the graph, it shows that the dessert can last in the frozen state for up to 20 minutes in tasting tests carried out at environmental temperatures of 20 °C to 26 °C. Given that the average duration of consuming a frozen dessert was reported as 15 minutes in the survey, the product is unlikely to change before the end of consumption in the absence of forces such as compressions and squeezing.

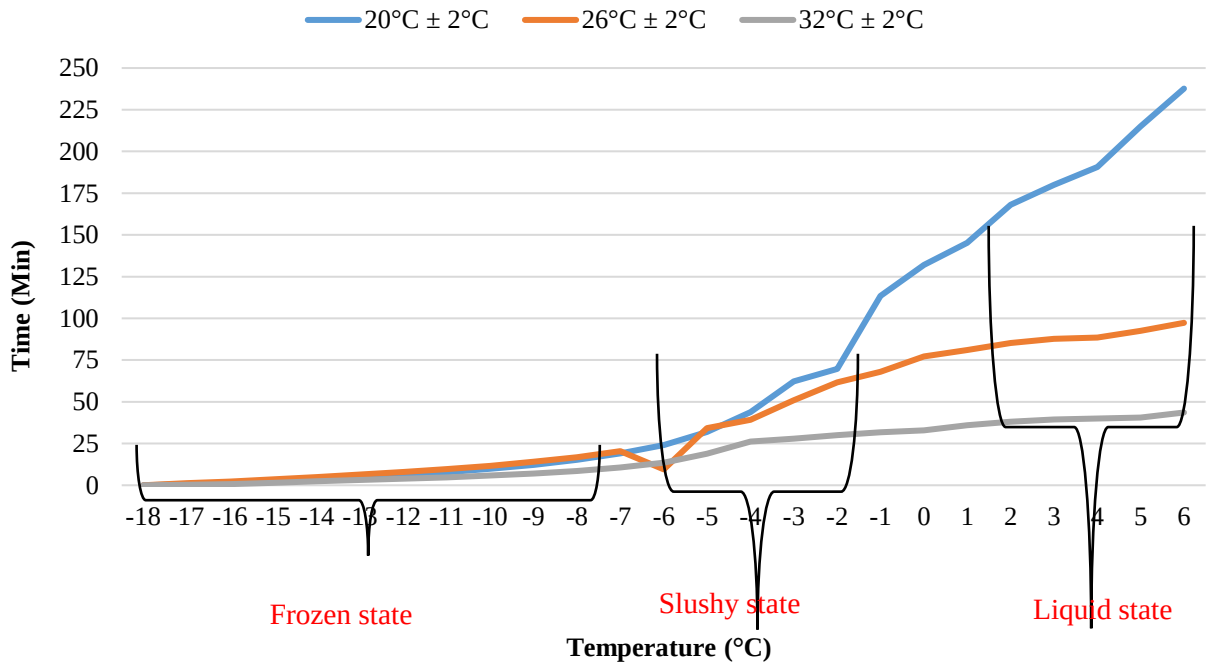

Figure 4.16: Time taken to thaw 100g of the frozen dessert at different environmental temperatures

Regardless of the length of time it took to achieve the various states, the physical outcome of the states was observed to be the same at the different environmental temperatures.

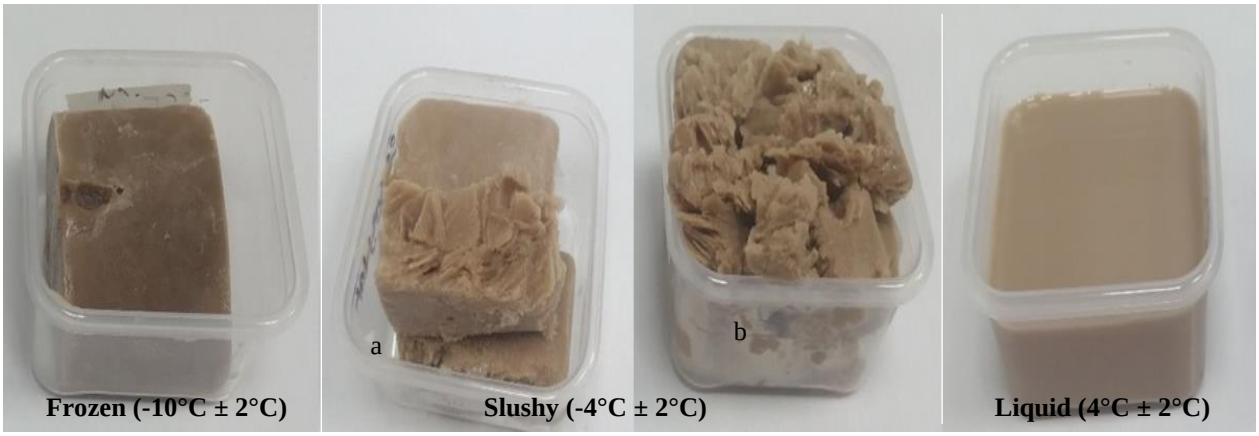

Figure 4.17: Physical states and corresponding temperatures of the frozen chocolate dessert

Figure 4.17 shows the various states of the product that were obtained and used in the subsequent evaluations. The compact (a) and crushed (b) forms of the slushy states shown in Figure 4.17 were both at -4°C. The crushed form was achieved by poking with a fork. The slushy state used in the tests was the compact form (a).

4.4 DETERMINING THE OPTIMUM TEMPERATURE FOR THE PROFILING OF FROZEN CHOCOLATE FLAVOURED MILK DESSERT

The descriptive evaluations were completed with 8 trained assessors (4 males and 4 females) with panel experience ranging from 6 months to 3 years. Term generation and consensus by the panel resulted in 16 attributes altogether that were used in the course of the descriptive tests (See Appendix 7). They comprised of 2 appearance terms, 2 aroma terms, 4 flavour terms, 3 mouth feel terms and 5 aftertaste/aftereffect terms.

4.4.1 Quantitative descriptive analysis (QDA®)

Thirteen (13) attributes were originally generated by QDA® to describe the samples. The attributes that were not used in the QDA® were melty mouth feel, runny mouth feel and bitter aftertaste as they sprung up during the temporal tests. For each physical state all sensory modalities were assessed and evaluated i.e. appearance, aroma, flavour, mouth feel and aftertaste.

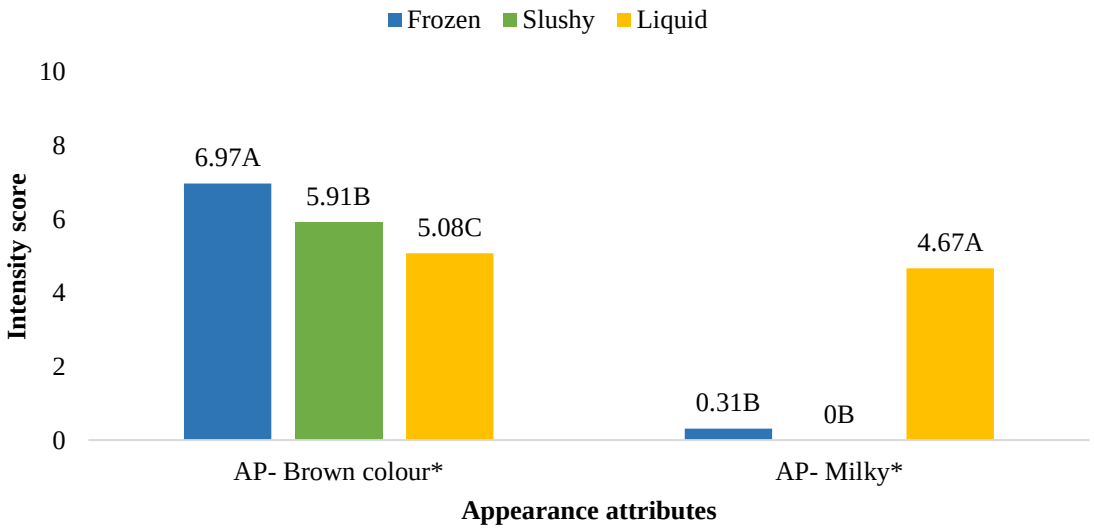

Figure 4.18: Appearance profile of the frozen desserts at different states

***** Statistically significant, same alphabets denotes no statistical difference at 95% confidence level

The physical state of the product had an effect on the colour of the product. The product in the frozen state was darkest in brown colour whilst the product in liquid state was lightest in brown. In addition, the product in liquid state appeared milky. This attribute was not observed in the solid forms of the product (i.e. frozen or slushy).

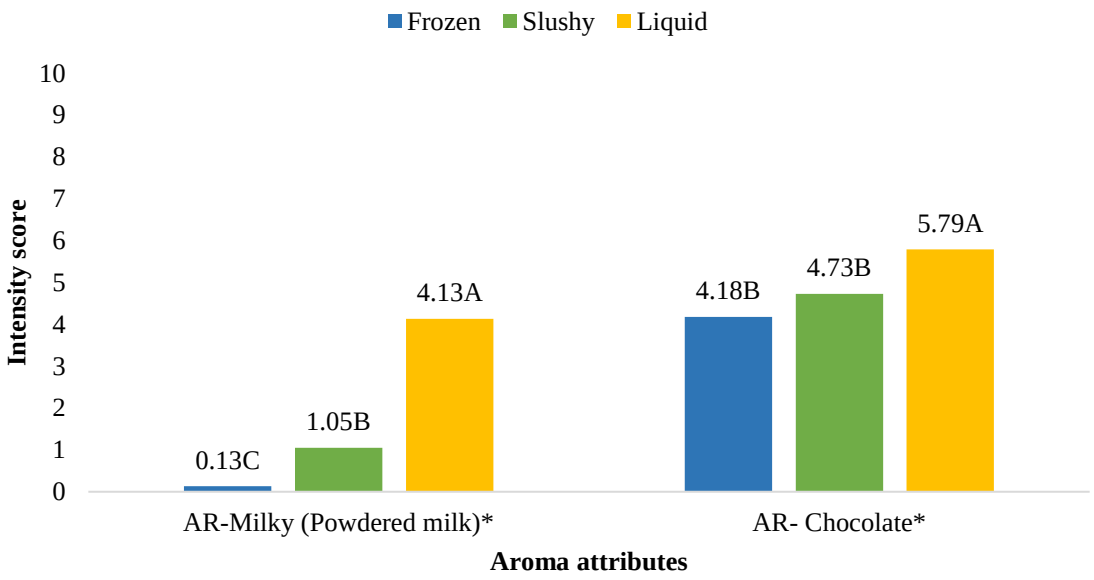

Figure 4.19: Aroma profile of the frozen desserts at different states
***** Statistically significant, same alphabets denotes no statistical difference at 95% confidence level

The physical states differed also in milky and chocolate aromas (Figure 4.19). The product in the liquid form had the most intense milky and chocolate aromas. The product in the frozen form had negligible intensity in milky aroma but did not differ from the slushy state in chocolate aroma. The physical state of a product influences the escape of volatiles, with heightened perceptions in the liquids (Pohjanheimo, 2010). Also, the observation of higher perceptions in the liquid state is not unusual as it is reported that for most products aroma and flavour volatiles are easily perceived at a higher temperature than at a lower temperature (Ross & Weller, 2008). Also the physical state influences the release of volatiles.

The 4 flavour attributes differed significantly among the 3 physical states.

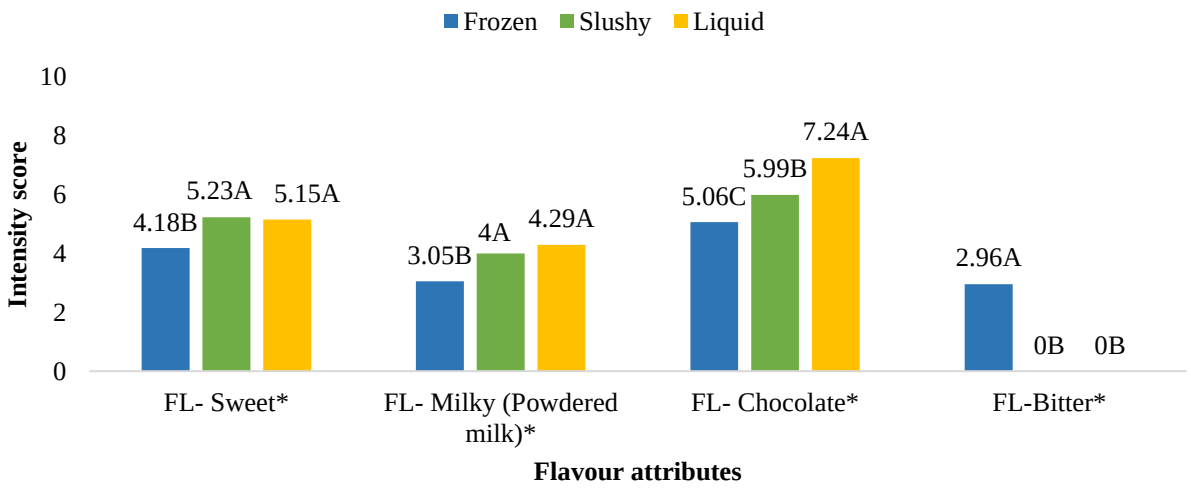

Figure 4.20: Flavour profile of the frozen desserts at different states

***** Statistically significant, same alphabets denotes no statistical difference at 95% confidence level

From Figure 4.20, it was observed that the frozen state was the least intense in sweetness, milky and chocolate taste. The liquid and slushy states differed significantly between each other for chocolate flavour only. Studies by Cliff and King (2009) and Lipscomb et al. (2016) reported that sweetness and perception of flavour notes increase with increasing temperatures. Bitter perception increased with decreased temperature as observed in the frozen state. Bajec et al. (2012) reported a similar negative relationship where bitter solutions were observed to increase with decreasing temperatures.

There were obvious textural differences among the different physical states of the product.

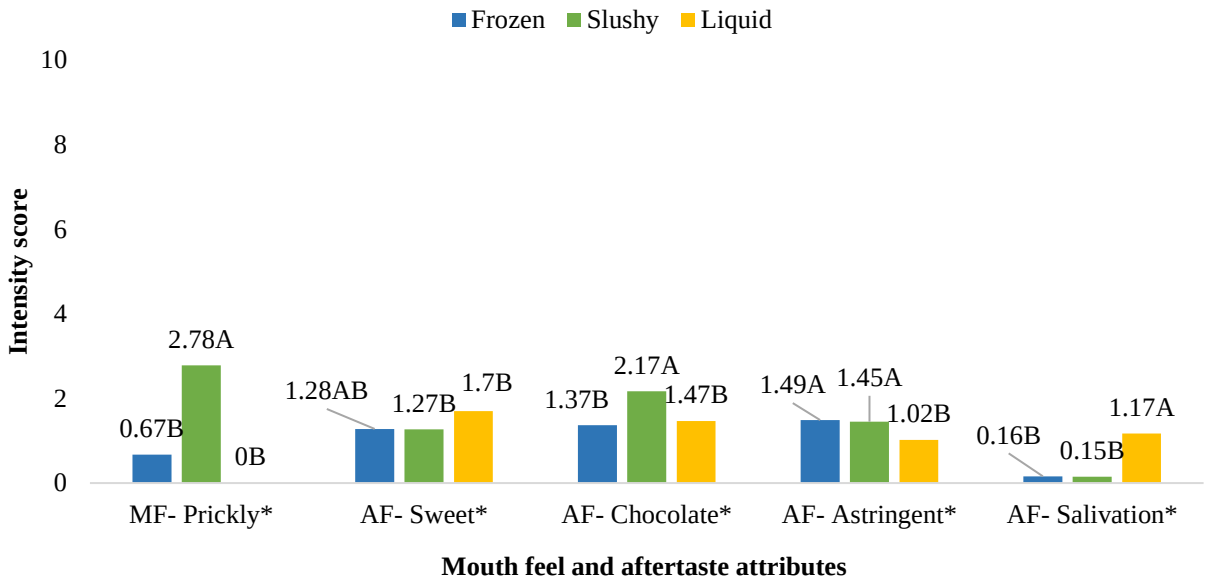

Figure 4.21: Mouth feel and aftertaste profile of the frozen desserts at different states

***** -Statistically significant, same alphabets denotes no statistical difference at 95% confidence level

The slushy state demonstrated prickling sensations in the mouth due to the exposure of the ice crystals. Aftertaste sweetness differed significantly between slushy and liquid states. Lingering chocolate taste was most intense in the slushy state. The liquid state was least astringent and elicited salivation. Astringency, which is a drying sensation in the mouth, reduces salivation resulting in a loss in lubrication. According to Gibbins and Carpenter (2012), astringency is often experienced alongside bitterness as was observed for the frozen state. This phenomenon has been reported to increase with colder temperatures (Ross & Weller, 2008) which could account for its presence in the slushy state as well.

4.4.2 Temporal dominance of sensations

Evaluations were on only in-mouth sensations. Three temporal related attributes were identified in TDS which were not elicited in the QDA; melty and runny mouth feels and bitter aftertaste. A total of 12 attributes from the attribute list in Appendix 7 were used (mouth feel – 3, flavour – 4 and aftertaste – 5). The chance and significant limits were determined based on the 12 attributes as 0.083 and 0.176 respectively.

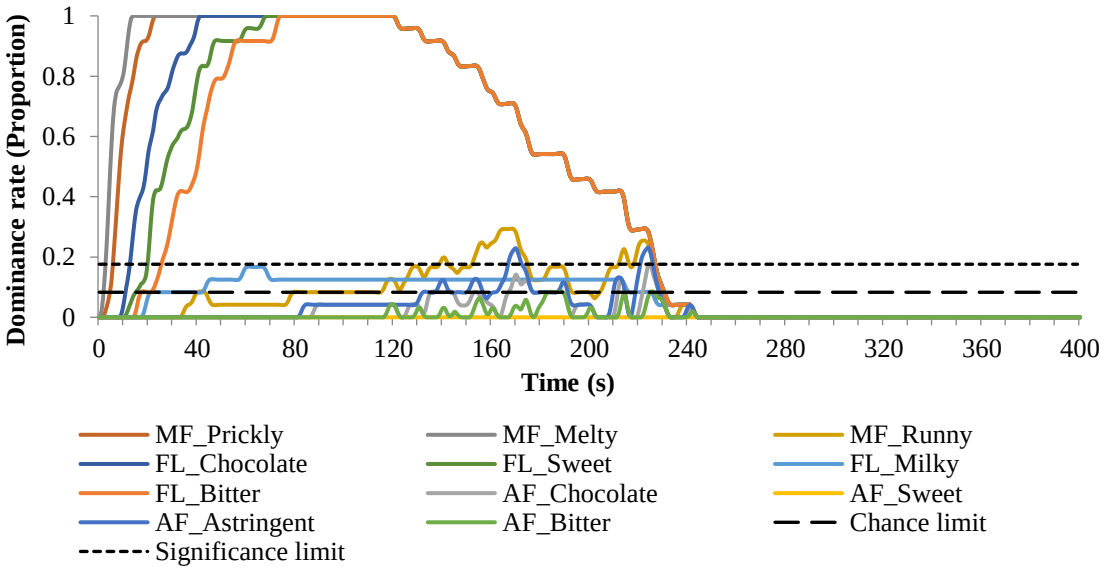

Figure 4.22: TDS curve of dominance rate (i.e. proportions of assessors scoring each attribute against time) for frozen state

From Figure 4.22, the total duration of the assessment was 240s. Only 11 attributes were selected as applicable to the product in the frozen state; the product did not induce salivation. This observation was also made from the QDA study. All but milky flavour, bitter aftertaste, chocolate aftertaste and sweet aftertaste were significant. The frozen state was dominated by bitter flavour for the longest part of the test. This observation was also made by the high intensity of bitter flavour

in the QDA study. Perceptions of aftertaste sensations were after 80s and selected by fewer assessors. Astringent aftertaste was significantly dominant although selections were low. This could be due to low acuity of such notes after the product was swallowed, possibly explaining the low scores of such attributes in QDA®.

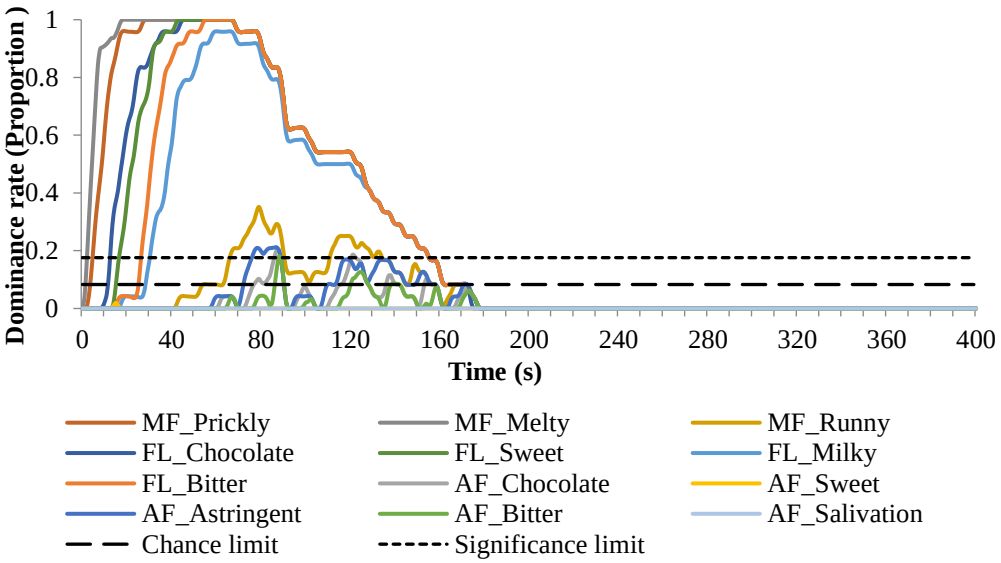

Figure 4.23: TDS curve of dominance rate (i.e. proportions of assessors scoring each attribute against time) for slushy state

From Figure 4.23, the total duration for the assessment of the slushy state was 180s. Of the 10 attributes that were selected as dominant, bitter aftertaste was not significant. Melty, prickly, bitter, sweet and chocolate flavours were observed to be predominant. Bitter taste was also dominant in slushy state although this was not observed in QDA® method. Bitter perception has been reported to be fleeting (Bajec et al., 2012) and could have been missed in QDA® which only makes evaluations at a uni-point. Astringent and chocolate aftertaste were significantly dominant in the slushy state. This was observed in QDA® too. Aftertaste notes were perceived after 60s and selected by fewer assessors denoting how low the perception of those notes were.

Seven in mouth attributes were selected as dominant in the liquid state (Figure 4.24). Melty and prickly did not apply to the liquid state.

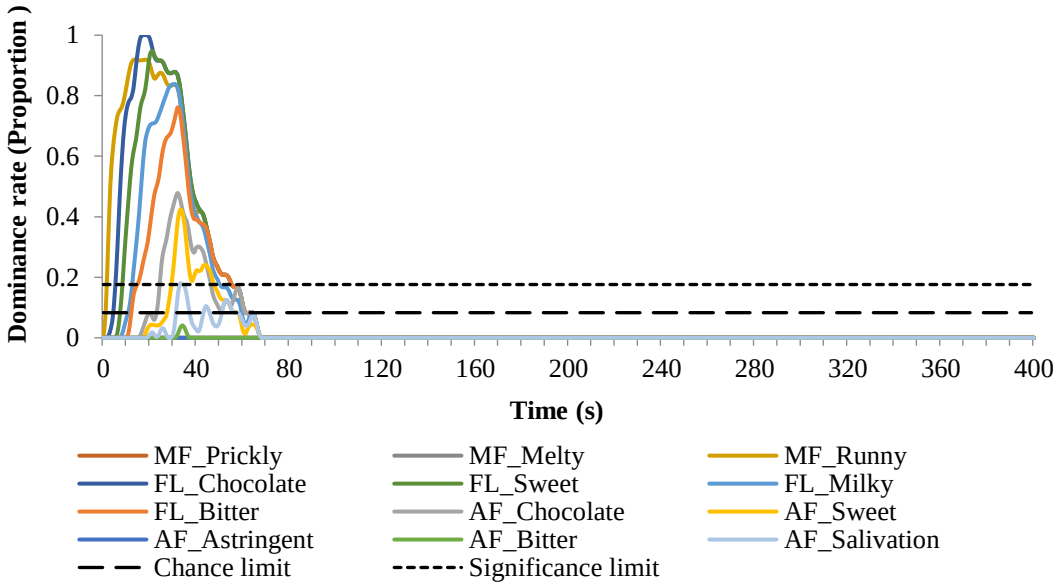

Figure 4.24: TDS curve of dominance rate (i.e. proportions of assessors scoring each attribute against time) for liquid state

From Figure 4.24, runny was selected as the first dominant attribute followed by the flavours chocolate, sweet and milky. All these attributes were selected within 10 seconds of intake. The temporal nature of TDS captured the perception of bitter taste as a dominant attribute in the liquid state after 20s although this was not perceived in the QDA®. Aftertaste chocolate and sweetness were also significantly dominant with selections by 50% of the assessors than observed for slushy and frozen states. The proportions may not be related to intensity as the slushy state had a slightly higher intensity in chocolate aftertaste in QDA® method. The liquid state neither elicited astringency nor induced salivation. This observation matched what was observed in the QDA® method. The total duration for the assessment of the liquid state was under 80s.

Differences between the frozen and slushy states were observed in the flavour notes and the duration of their perceptions.

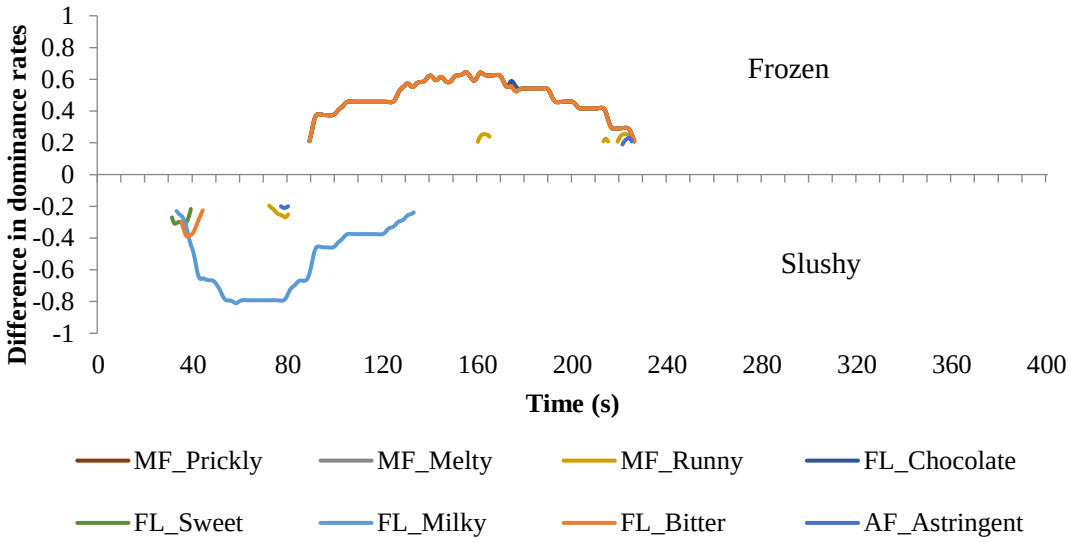

Figure 4.25: TDS difference curve between frozen (upper axis) and slushy (lower axis) states

From Figure 4.25, frozen state (upper axis) was observed to be significantly bitter in flavour and for a longer duration while slushy state (lower axis) was significantly milky in flavour. This observation can be likened to what was detected in the QDA®.

TDS differences between the frozen and liquid states were differentiated by mouth feel, flavour and aftertaste notes.

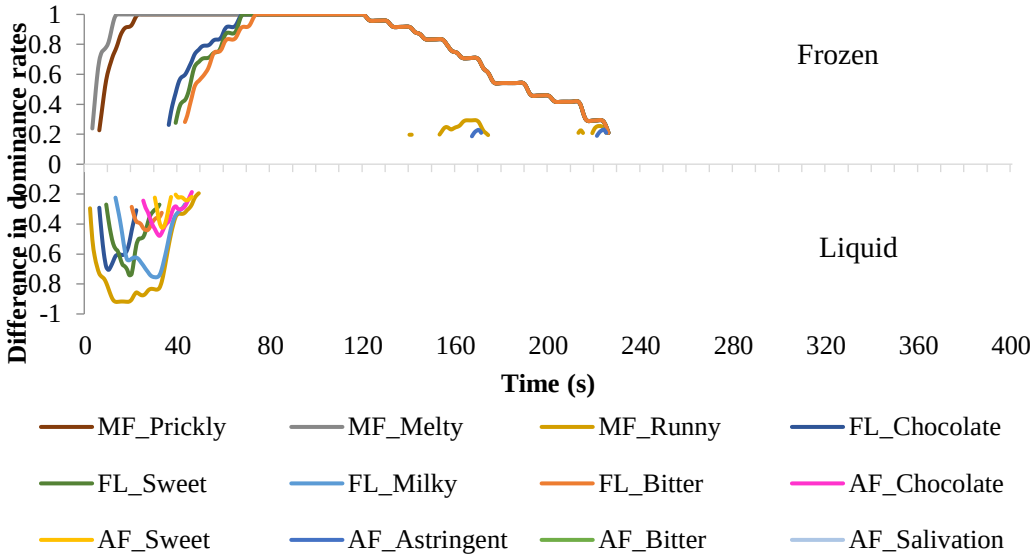

Figure 4.26: TDS difference curve between frozen (upper axis) and liquid (lower axis) states

Prickly and melty mouth feel characterized the frozen state (upper axis) while runny mouth feel characterized the liquid state (lower axis) as shown in Figure 4.26. Perception of chocolate, sweet and bitter was quicker and shorter in the liquid state than the frozen state. The frozen state was astringent while the liquid state was milky and had a lingering sweetness and chocolate taste.

Figure 4.27 shows textural differences between slushy (upper axis) and liquid (lower axis) with slushy characterized by melty and prickly mouth feel and liquid by runny.

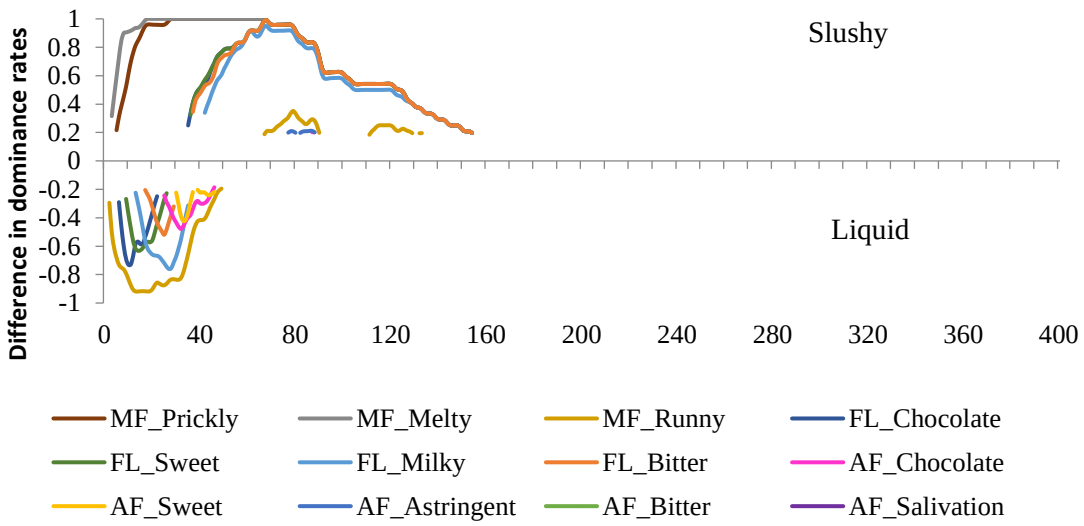

Figure 4.27: TDS difference curve between slushy (upper axis) and liquid (lower axis) states

Beside these obvious texture differences, both physical states were described as having sweet, chocolate and milky flavour notes, however perception of these notes were faster and shorter in the liquid state than the slushy state. Also bitter was perceived in the liquid state and this may have been missed in the QDA due to how quick and fleeting that sensation was. The liquid state also differed uniquely with a lingering sweetness and chocolate taste. The slushy state had a higher chocolate aftertaste and did not differ in lingering sweetness in the QDA® test.

The intensity scores of the attributes that discriminated between the products in terms of dominance were also significantly different as observed in Figure 4.28.

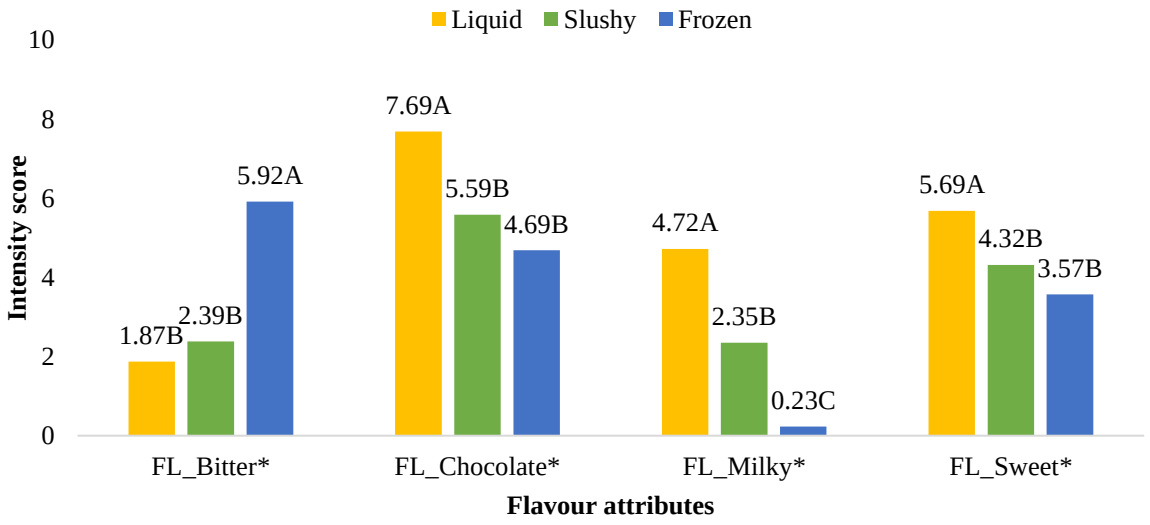

Figure 4.28: TDS intensity score of flavour sensations

***** Statistically significant, same alphabets denotes no statistical difference at 95% confidence level

The frozen state was the most intense in bitter sensation in TDS. Liquid and slushy states had low intensities of bitter although in QDA® they had no bitter taste. The liquid state had the most intense level of sweetness, milky and chocolate taste.

The intensity scores for mouth feel and aftertaste attributes were significantly different among the physical states except runny mouth feel as shown in Figure 4.29.

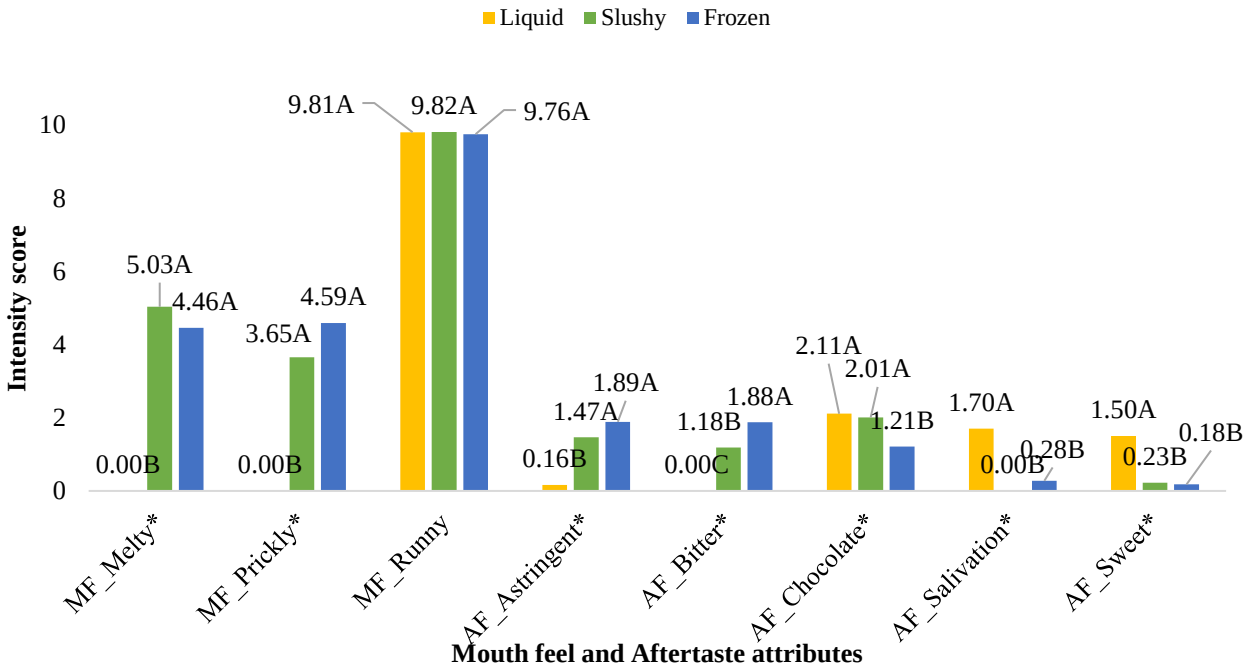

Figure 4.29: TDS intensity score of mouth feel and aftertaste sensations

Same alphabets denotes no statistical difference at 95% confidence level

Slushy state began melting in the mouth faster than the frozen state due to the loose nature of the ice crystals increasing the surface area. There was no statistical difference ($p>0.05$) in their intensity of prickling sensation. The slushy and frozen state were astringent which matches the observation made in QDA® test. Bitter aftertaste was significant among the states with frozen state recording the most intense followed by slushy state. The scores were however below 2 and this may be attributable to the insignificance of this attribute during comparisons of curve differences. Liquid and slushy states possessed lingering taste of chocolate although in QDA® slushy was the only state that had a significantly higher chocolate aftertaste. The liquid state had a lingering sweetness and matched the observation in the QDA® test.

The first 2 principal components (PCs) completely loaded all the product attributes for QDA® (F1= 72.6%, F2= 27.4%) and TDS intensity methods (F1= 85.56%, F2=14.44%).

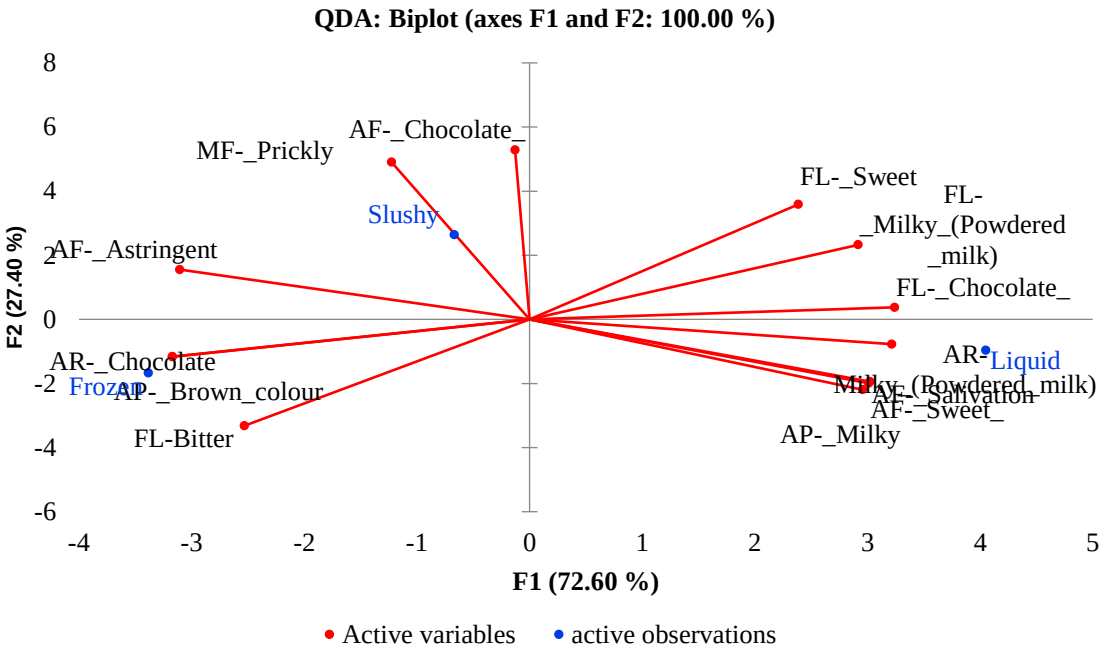

Figure 4.30: Principal component analysis biplot from QDA scores

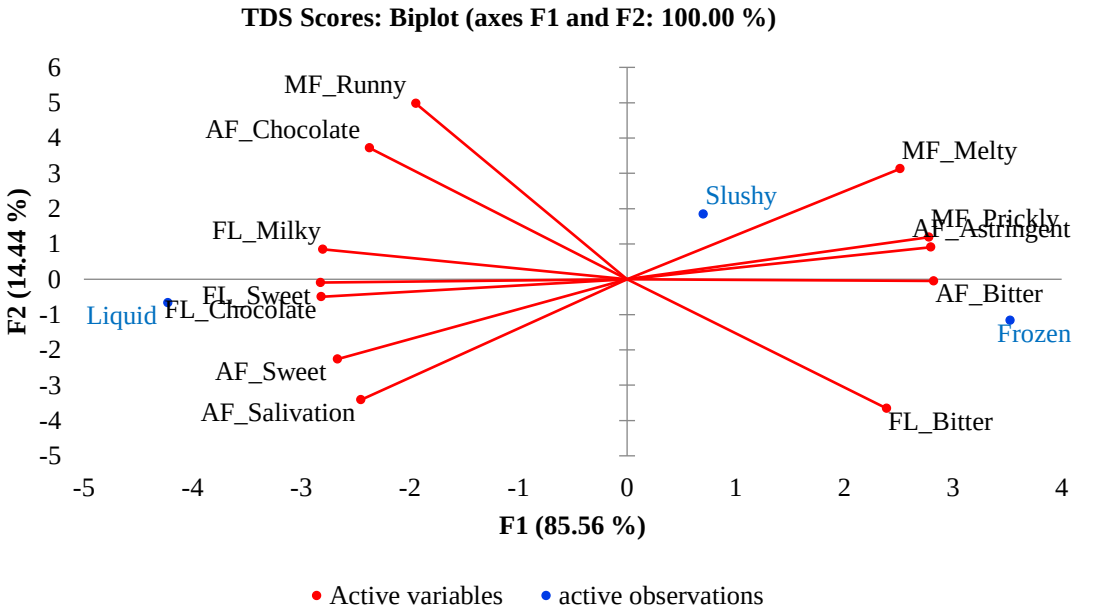

Figure 4.31: Principal component analysis biplot from TDS intensity scores

Visual inspection of the biplots show the two methods loaded the samples around the same attributes in the sensory space as seen in Figures 4.30 and 4.31 (Ng et al., 2012). Considering only in-mouth sensations, the liquid state was loaded around more attributes compared to the other states. It was described by sweet, milky and chocolate flavours; sweet aftertaste and salivation in both methods. Slushy state was loaded in the upper quadrant and described by prickly and astringent in both methods and aftertaste chocolate in QDA® and melty in TDS. Frozen state was loaded in the quadrant under slushy in both methods. It was characterized by bitter flavour in both methods and bitter aftertaste in TDS. Frozen state was loaded close to slushy state and opposite liquid state in both methods. This shows how the perceptions of attributes are greatly influenced by the physical state and by extension the temperature of the products.

4.4.3 Temporal Check All That Apply

Like the TDS method, evaluations were on only in-mouth sensations. The same 12 attributes used in TDS were applicable to TCATA (mouth feel – 3, flavour – 4 and aftertaste – 5). The higher the proportion of citations for an attribute, the stronger the panel consensus (Nguyen et al., 2018).

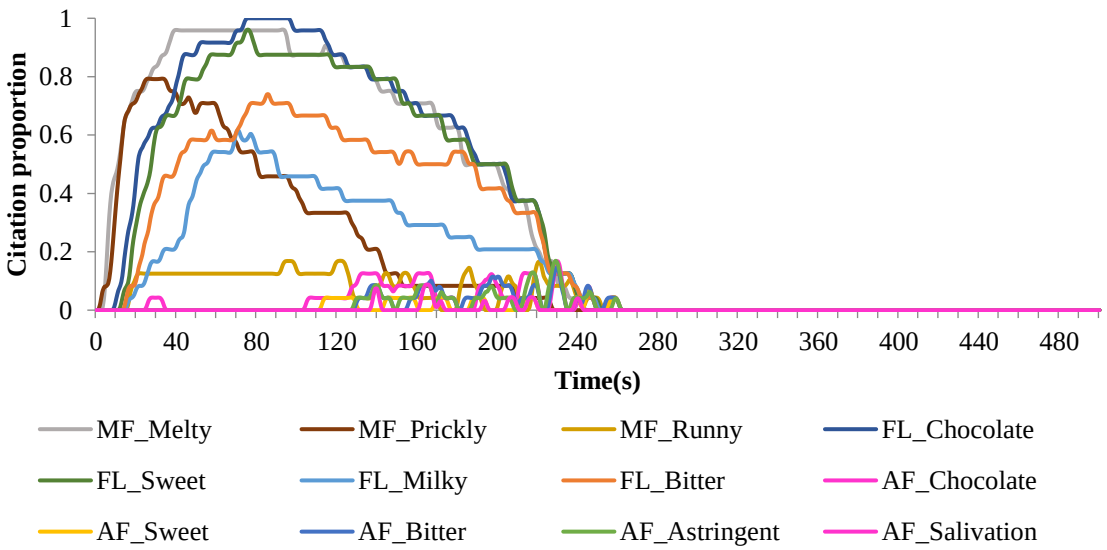

Figure 4.32: TCATA curve showing proportions of assessors selecting each attribute against time) for the frozen state

The overall duration of the assessment was about 260s as shown in Figure 4.32. There were multiple citations of melty, prickly, chocolate, sweet and milky attributes by more than 50% of the assessors depicting a strong panel consensus (Nguyen et al., 2018). Milky was perceived in the frozen state because the focus was not based on dominance and got the opportunity of inclusion. There was low panel consensus on the perception of aftertaste sweet, aftertaste chocolate and aftertaste bitter.

From Figure 4.33, the overall duration for the assessment of the dessert in the slushy state was about 200s.

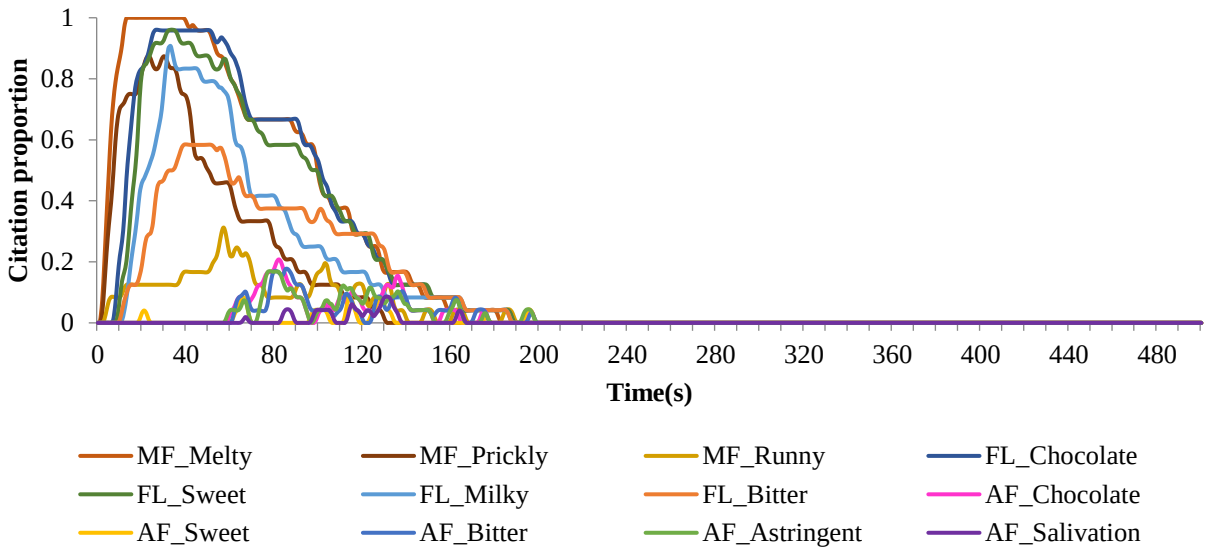

Figure 4.33: TCATA curve showing proportions of assessors selecting each attribute against time for the slushy state

The slushy state was characterized first by prickly and melty; and then chocolate, sweet and milky. Bitter taste was perceived for the slushy state as well (more that 50% of the panel) although this perception was not made in QDA®.

From Figure 4.34, the temporal assessment of the liquid state spanned about the same duration (80s) as observed in TDS.

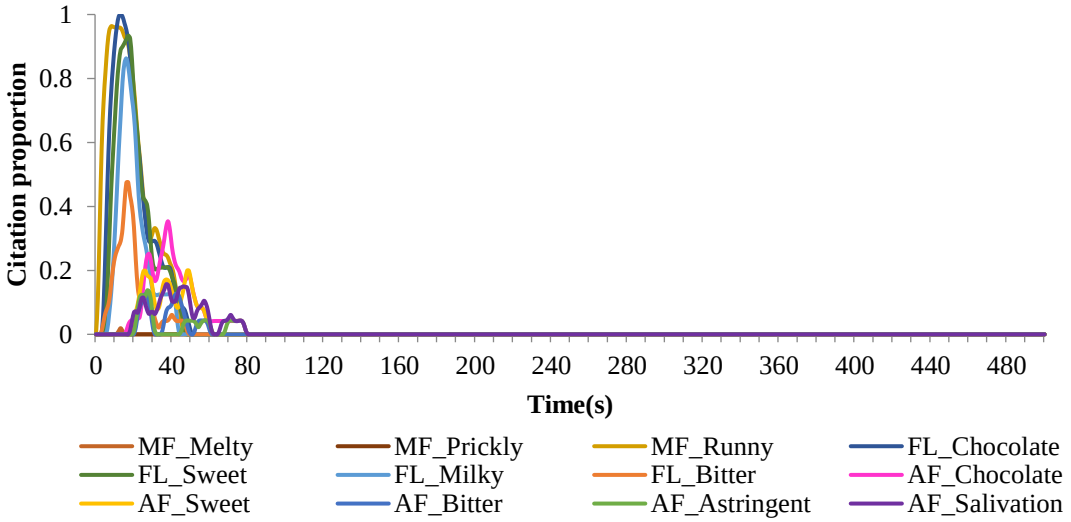

Figure 4.34: TCATA curve showing proportions of assessors selecting each attribute against time for the liquid state

Under 10s, runny, chocolate, sweet and milky characterized the product in the liquid state and continued until at 40s. Bitter flavour was also observed in the liquid state although this attribute received a score of 0 in the QDA® method. Aftertaste bitter, astringent and salivation received fewer citations depicting low panel consensus for those attributes.

The two states shared almost the same attributes with differences observed mainly on the time points and duration of perceptions as seen in Figure 4.35.

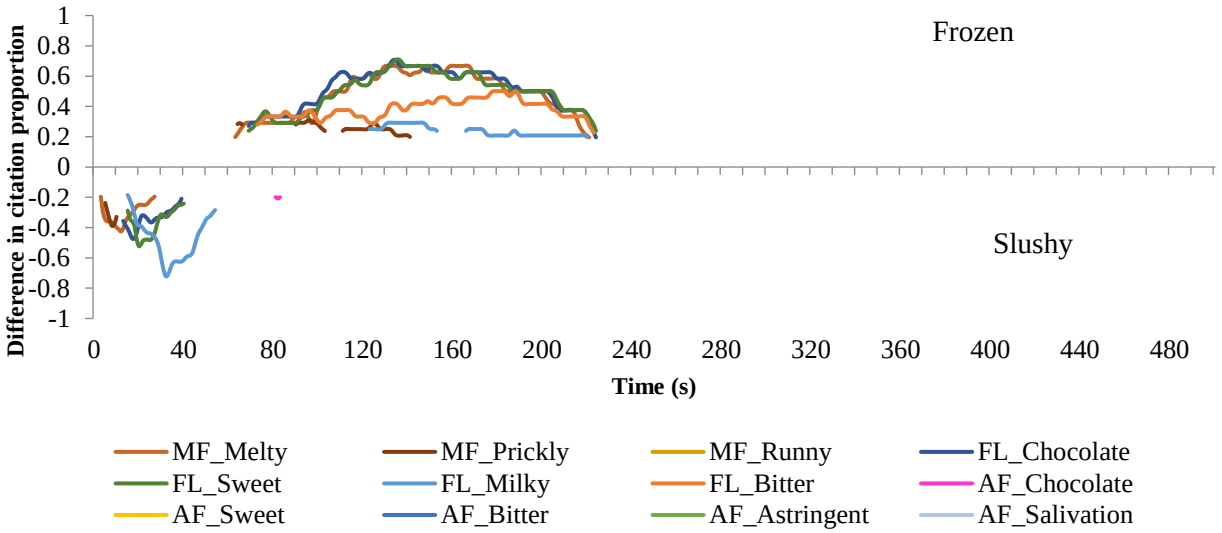

Figure 4.35: TCATA difference curve between frozen (upper axis) and slushy (lower axis) states

Perceptions in slushy (lower axis) were faster and for a shorter duration than the frozen state (upper axis). The frozen state was distinctively bitter while the slushy state registered a moment of significant lingering chocolate taste.

Observations from Figure 4.36 shows vast differences between the frozen and liquid states with relation to attributes and the duration of perceptions.

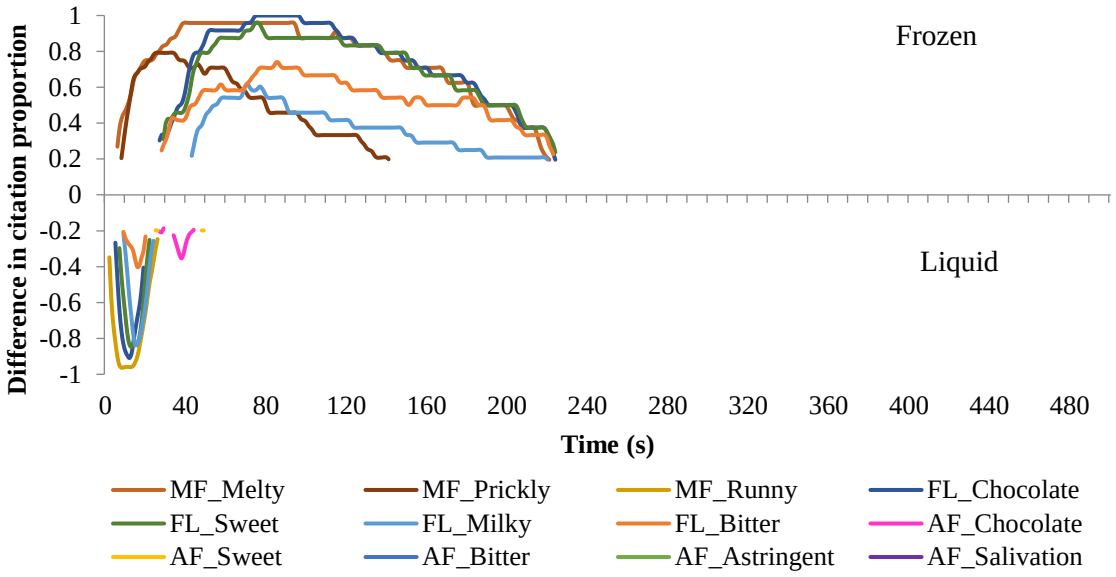

Figure 4.36 TCATA difference curve between frozen (upper axis) and liquid states (lower axis)

Perceptions in the liquid state (lower axis) occurred quicker and for a shorter duration than the frozen state (upper axis) that had perceptions for longer durations. There were textural differences observed between the two states with the frozen state characterized by melty and prickly and the liquid state by runny. There were transient moments of bitterness and lingering chocolate taste observed in the liquid state.

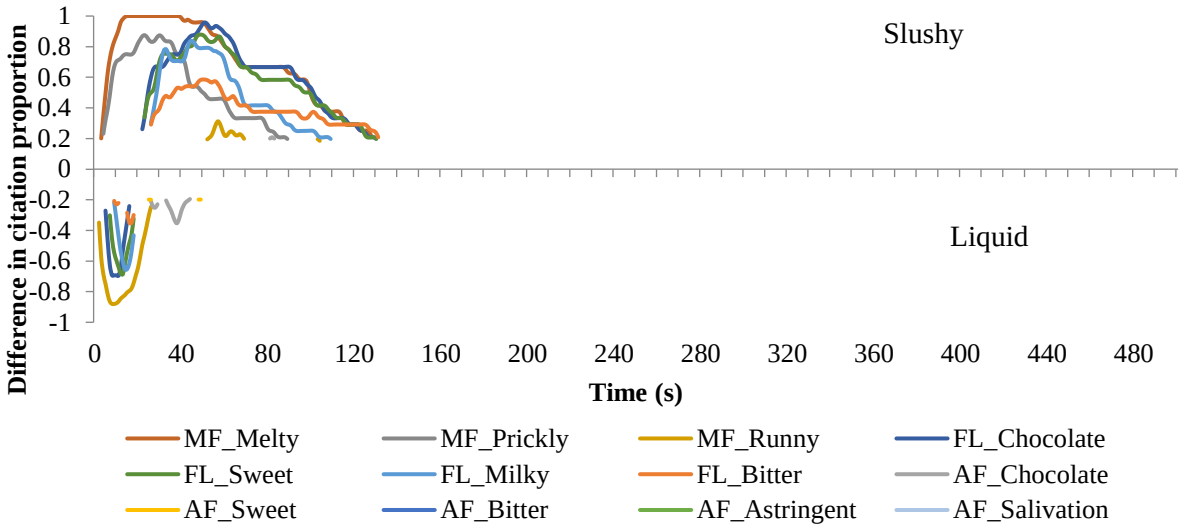

Figure 4:37 TCATA difference curve between slushy (upper axis) and liquid (lower axis) states

The slushy state (upper axis) differed from the liquid state (lower axis) with melty and prickly mouth feel. From Figure 4.37, overall differences in the flavour attributes were on the duration of perceptions between the two states where perceptions were quicker and for a shorter duration in the liquid state than the slushy state even for bitter flavour. The liquid state differed with transient lingering sweetness and chocolate taste.

4.6 ESTABLISHING THE PROS AND CONS OF USING DIFFERENT THE PROFILING METHODS

It was observed that both TDS and TCATA captured the temporality of the physical forms using the same attributes and gave comparable results (Ares et al., 2017). The total duration of each state in both TDS and TCATA were close.

Table 4.5: Comparison of QDA, TDS and TCATA

	QDA	TDS (with scores)	TCATA
Number of flavour, mouth feel and after effects attributes	10	12	12
Intensity scores	Yes	Yes (with scores)	No
Discrimination	Yes	Yes	Yes
Duration of evaluations (x3 for triplicate)	Longer (280-320s)	Close (70-240)	Close (80-260)
Quantity of products per tasting	40g	10g	10g
Captures temporality	No	Yes	Yes
Time spent on test pre-training	–	6 sessions	3 sessions
Time spent on test post-training ((3 hours per session)	9 sessions	6 sessions	3 sessions
Level of difficulty	–	Medium	Low

Table 4.5 above shows the comparison of TDS and TCATA to QDA. Both methods revealed two extra attributes in addition to the QDA attribute list. Both temporal test methods demonstrated qualitative differences between the different states of the product. TDS also provided intensity scores which grouped the states in similar sensory space as the QDA ® as observed in Figures 4.30 and 4.31 (Bord et al., 2019; Ng et al., 2012). This suggests that TDS measurements of dominant attribute intensity reflect those provided by QDA, as was also concluded by Labbe et al. (2009).

QDA took the longest time to execute among the 3 test methods (Di Monaco et al., 2014), followed by TDS with the introduction of intensity scoring. The trained panel indicated that between the

TDS and TCATA, the latter was relatively easy to execute due to the absence of intensity scoring. Both TDS and TCATA captured the dynamic nature of attribute perception. Unlike TDS, TCATA allowed multiple selections of perceivable attributes at a time and showed the most complete description of the states, hence milky for instance was applicable in the frozen state which TDS did not capture (Esmerino et al., 2017; Ng et al., 2012; Nguyen et al., 2018).

TDS and TCATA apart from requiring a shorter time for execution also utilized less samples than QDA®. Both temporal tests however are highly software dependent for data collection due to the bulky amount of information gathered in miniscule time-points.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The consumption style by which Ghanaians consume frozen dairy-based desserts packaged in plastic pouches was identified. The study revealed that Ghanaians enjoyed this kind of desserts in the slushy form which they achieve by allowing the product time to thaw in its original pouch. The products were mostly consumed by taking bites and it takes the Ghanaian an average of 15 minutes to completely consume such products. The respondents indicated that the physical states and product temperatures influence how much they like these kinds of frozen desserts.

The corresponding temperatures of the frozen, slushy and liquid states and the average time it took to achieve them were also determined. Approximately 100g of the dessert in the frozen state took about 20 minutes to change into the slushy state and about 30 minutes to change from that state to the liquid state when tested under environmental temperature ranges of 20°C to 26 °C. Therefore, considering the average time it takes for consumption, the frozen dessert is likely to remain unchanged in the physical state throughout the consumption experience.

The highest point of consumer liking was also determined. Consumer acceptability of the frozen desserts were influenced by the physical states of the product. The liquid state was the most liked among the three states and the frozen state was the least liked. The time-point of consumption also influenced liking scores as all the states were liked the most at the end of product consumption.

Quantitative Descriptive Analysis (QDA®) was used to determine the optimum temperature and state for profiling of these frozen products. There were significant differences in the appearance, aroma, flavour, mouth feel and aftertaste among the 3 physical states of the frozen dessert. Bitterness was only perceived in the frozen state. The slushy state was in between the two states

for all the sensory attributes, but closer to the frozen state. The liquid state demonstrated a higher perception of aroma and flavour notes.

The polyethylene sachet packaged frozen dessert changed state with temperature and time. To understand this temporal nature of the product, Temporal Dominance of Sensation (TDS) with intensity scaling and Temporal Check All That Apply (TCATA) were used to characterize the product in the 3 physical states and compared to QDA®. The two temporal methods introduced 3 extra attributes melty, runny mouth feels and bitter aftertaste. The two methods both showed product discrimination for all the attributes except bitter aftertaste. TDS only captured attributes that were considered dominant. TDS intensity scores was comparable to QDA® scores as both characterized the physical states in similar axes in the sensory space. TCATA captured all attributes that were perceivable in the product giving a complete product description. The temporal methods established the evolution of the attributes that characterized the frozen desserts and thus useful in profiling frozen desserts depending on the overall objective. Both temporal methods also required a lesser time and quantity for evaluations compared to QDA®. TCATA was relatively easier to execute than TDS because it did not require intensity scoring.

5.2 RECOMMENDATION

5.2.1 Recommendation for implementations

Recommended sensory profiling state for the frozen desserts that come packaged in polyethylene pouches is the slushy state as it was indicated as the physical state such desserts are mostly consumed. It was also intermediary of the two other states in sensory properties.

Frozen desserts in the frozen or slushy states should be consumed by taking bites and not sucking of juices to prevent loss of flavour during the consumption experience.

In consumer studies, acceptability scores should be collected at the end of the product consumption experience.

For the chocolate flavoured frozen desserts specifically, to evaluate an attribute such as bitter, an exception of the assessment to be done in the frozen state could be made. Evaluation in the liquid state using QDA® would require additional training of panel to pick up on transient attributes like bitter taste.

The temporal methods are useful in understanding the temporal behavior and rapid profiling of frozen desserts given the product categories unstable nature. The methods can serve as suitable substitutes given the specific objectives.

- TCATA will be useful in obtaining a quick qualitative overview of a products profile especially new or improved products while capturing even the transient of attributes particularly subtle off notes.
- TDS will be useful in capturing the key attributes of improved or original products as it evolves with time both qualitatively and quantitatively.

Table 5.1: Recommended protocols/guidelines for characterizing frozen desserts packaged in polyethylene pouches

	TEST	PHYSICAL STATE & TEMPERATURE	PROS	CONS	REMARKS
	Consumer acceptance	Slushy (-4°C± 2°C)			• Liking score should be collected at the end of consumption when about 50g is served. • In the event that a full pouch is provided, scoring can be collected after consumption of 1/3 of product. • Product should be consumed only with bites (Should not be sucked on) • Should be presented in original pouch or tied in polyethylene bags to depict pouches • Testing of products should be under environmental conditions within 20°C to 26°C. • Product can stay unchanged in the slushy and frozen state for about 20 minutes before any form change during consumption of product in a consumer test.
Preamble	QDA®		Provides qualitative and quantitative information about a product.	• QDA requires relatively more quantities of	• Product should be presented to panel and consumed as described under consumer acceptance

				products and time. • Does not capture the evolution of attributes and hence can miss out on some hidden attributes depending on the physical state and serving temperature.	
		Slushy (-4°C± 2°C)	Depicts normal consumption state of such desserts		Product should be presented to panel and consumed as described under consumer acceptance
		Frozen state (-10°C± 2°C)	Captures attributes that are perceptible at colder	• Low perception of volatiles that are perceptible at higher	• Should be presented to panel and consumed as described under consumer acceptance

			temperatures (e.g. bitter)	temperatures (most flavour notes)	
		Liquid state (4°C± 2°C)	• Promotes perception of attributes easily. • Useful if the frozen dessert would be repurposed as a beverage in the liquid state.	• Low perception of transient notes like bitter.	• Panels require additional training to pick up such notes
Preamble	Temporal tests	Slushy state (-4°C± 2°C)	• Evolution of textural and flavour notes observed in frozen and liquid state can be adequately captured in slushy state.		• Should be presented to panel and consumed as described under consumer acceptance

			• Quick to complete • Requires less quantity of product. • Relatively faster		
	TDS		• Captures dominant notes. • Useful in old products or improved versions.	• Only captures the profile of the product qualitatively. • TDS may generally miss background attributes and subtle off notes as it focuses only on the attributes that are deemed to be standout.	

	TDS Intensity scores	Slushy state (-4°C± 2°C)	• Captures intensity of dominant notes. • Evolution of textural and flavour notes observed in frozen and liquid state can be adequately captured in slushy state. • Quick to complete	• TDS intensity score may generally miss background attributes and subtle off notes as it focuses on attributes that standout. • May require improvisation in the absence of specialized software	
	TCATA	Slushy state (-4°C ± 2°C)	• Provides a complete overview of the product and can flag transient notes as well as subtle off notes. • Useful in evaluation new products or	• Provides only a qualitative profile of products.	

			improved products. • Relatively easier to complete		

5.2.2 Recommendation for further studies

i. Explore temporal liking method to investigate the evolution of consumer acceptance of frozen desserts in the solid physical state to substantiate the point at which liking is highest during consumption.

ii. Investigate the adaptability of using TCATA and TDS methods by untrained panel (consumers) to characterize frozen desserts as rapid method for profiling.

iii. Qualitative research on the evolution, production and consumer trends of frozen desserts in Ghana.

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APPENDICES

Appendix 1: ANOVA AND TUKEY'S COMPARISON – PRELIMINARY STUDY (CONSUMPTION STYLE STUDY)

General Linear Model: Liking_at_first_taste versus Sample_Name, Assessor_Code

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	1	1.286	1.2857	3.55	0.082
Assessor_Code	13	14.857	1.1429	3.15	0.024
Error	13	4.714	0.3626		
Total	27	20.857			

General Linear Model: Liking after consumption versus Sample_Name, Assessor_Code

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	1	0.5714	0.5714	1.00	0.336
Assessor_Code	13	5.0000	0.3846	0.67	0.757
Error	13	7.4286	0.5714		
Total	27	13.0000			

General Linear Model: Overall_Liking Experience versus Sample_Name, Assessor_Code

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	1	0.8929	0.8929	3.22	0.096
Assessor_Code	13	10.1786	0.7830	2.82	0.036
Error	13	3.6071	0.2775		
Total	27	14.6786			

Comparisons for Liking_at_first_taste

Tukey Pairwise Comparisons: Response = Liking_at_first_taste, Term = Sample_Name

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Name	N	Mean	Grouping
PLS02	14	7.78571	A
PLS01	14	7.35714	A

Means that do not share a letter are significantly different.

Comparisons for Liking after consumption

Tukey Pairwise Comparisons: Response = Liking after consumption, Term = Sample_Name

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Name	N	Mean	Grouping
PLS02	14	7.64286	A
PLS01	14	7.35714	A

Means that do not share a letter are significantly different.

Comparisons for Overall_Liking Experience

Tukey Pairwise Comparisons: Response = Overall_Liking Experience, Term = Sample_Name

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Name	N	Mean	Grouping
PLS02	14	7.78571	A
PLS01	14	7.42857	A

Means that do not share a letter are significantly different.

ANOVA - CHOCOLATE FLAVOURED FROZEN MILK DRINK VS TIME-POINT, ASSESSOR

Source	DF	Adj. SS	Adj. MS	F-value	p-value
Time-point	2	0.0476	0.02381	0.06	0.943
Assessor	13	13.2381	1.01832	2.49	0.0023
Error	26	10.619	0.40842		
Total	41	23.9048			

TUKEY'S COMPARISON CHOCOLATE FLAVOURED FROZEN MILK DRINK

Time-point	Mean	Grouping
First taste	7.36	A
Last taste	7.36	A
Overall experience	7.43	A

ANOVA STRAWBERRY FLAVOURED FROZEN DESSERT VS TIME-POINT, ASSESSOR

Source	DF	Adj. SS	Adj. MS	F-value	p-value
Time-point	2	0.1905	0.09524	0.48	**0.623**
Assessor	13	16.7857	1.29121	6.53	0.000
Error	26	5.1429	0.1978	0.48	
Total	41	22.119			

TUKEY'S COMPARISON STRAWBERRY FLAVOURED FROZEN DESSERT

Time-point	Mean	Grouping
first taste	7.79	A
Last taste	7.64	A
Overall experience	7.79	A

Appendix 2: ANOVA AND TUKEY'S COMPARISON – CONSUMER ACCEPTANCE TEST ON 3 STATES OF CHOCOLATE FLAVOURED DESSERT

General Linear Model: First taste versus Sample_Name, Assessor_Code

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	2	48.86	24.429	18.06	0.000
Assessor_Code	83	197.38	2.378	1.76	0.001
Error	166	224.48	1.352		
Total	251	470.71			

Comparisons for First taste

Tukey Pairwise Comparisons: Response = First taste, Term = Sample_Name

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Name	N	Mean	Grouping
LIQUID	84	7.57143	A
SLUSHY	84	7.14286	B
FROZEN	84	6.50000	C

Means that do not share a letter are significantly different.

General Linear Model: Mid-way tasting versus Sample_Name, Assessor_Code

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	2	35.31	17.655	16.65	0.000
Assessor_Code	83	212.77	2.564	2.42	0.000
Error	166	176.02	1.060		
Total	251	424.11			

Comparisons for Mid-way tasting

Tukey Pairwise Comparisons: Response = Mid-way tasting, Term = Sample_Name

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Name	N	Mean	Grouping

LIQUID	84	7.73810	A
SLUSHY	84	7.26190	B
FROZEN	84	6.82143	C

Means that do not share a letter are significantly different.

General Linear Model: Overall_Liking versus Sample_Name, Assessor_Code

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	2	40.98	20.492	16.49	0.000
Assessor_Code	83	179.00	2.157	1.73	0.001
Error	166	206.35	1.243		
Total	251	426.33			

Comparisons for Overall_Liking
Tukey Pairwise Comparisons: Response = Overall_Liking, Term = Sample_Name

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Name	N	Mean	Grouping
LIQUID	84	8.08333	A
SLUSHY	84	7.46429	B
FROZEN	84	7.10714	B

Means that do not share a letter are significantly different.

General Linear Model: FROZEN versus PANEL, TIME-POINT

TIME-POINT: first taste, Mid-way, Overall liking

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
PANEL	83	428.86	5.1670	14.18	0.000
TIME-POINT	2	15.50	7.7500	21.26	0.000
Error	166	60.50	0.3645		
Total	251	504.86			

Comparisons for FROZEN

Tukey Pairwise Comparisons: Response = FROZEN, Term = TIME-POINT

Grouping Information Using the Tukey Method and 95% Confidence

TIME-POINT	N	Mean	Grouping
Overall liking	84	7.10714	A
Mid-way	84	6.82143	B
first taste	84	6.50000	C

Means that do not share a letter are significantly different.

General Linear Model: SLUSHY versus PANEL, TIME-POINT

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
PANEL	83	318.520	3.8376	9.52	0.000
TIME-POINT	2	4.437	2.2183	5.50	0.005
Error	166	66.897	0.4030		
Total	251	389.853			

Comparisons for SLUSHY

Tukey Pairwise Comparisons: Response = SLUSHY, Term = TIME-POINT

Grouping Information Using the Tukey Method and 95% Confidence

TIME-POINT	N	Mean	Grouping	
Overall liking	84	7.46429	A	
Mid-way	84	7.26190	A	B
first taste	84	7.14286		B

Means that do not share a letter are significantly different

General Linear Model: LIQUID versus PANEL, TIME-POINT

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
PANEL	83	275.35	3.3174	12.00	0.000
TIME-POINT	2	11.45	5.7262	20.72	0.000

Error	166	45.88	0.2764
Total	251	332.68	

Comparisons for LIQUID

Tukey Pairwise Comparisons: Response = LIQUID, Term = TIME-POINT

Grouping Information Using the Tukey Method and 95% Confidence

TIME-POINT	N	Mean	Grouping
Overall liking	84	8.08333	A
Mid-way	84	7.73810	B
first taste	84	7.57143	B

Means that do not share a letter are significantly different.

Appendix 3: ANOVA AND TUKEY'S PAIRWISE COMPARISON OF QDA®

General Linear Model: AR-Milky_ versus Sample_Name, Assessor_Code, Session_Number

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	2	210.962	105.481	229.31	0.000
Assessor_Code	7	7.534	1.076	2.34	0.035
Session_Number	2	2.520	1.260	2.74	0.073
Error	60	27.600	0.460		
Total	71	248.617			

General Linear Model: AR-_Chocolate versus Sample_Name, Assessor_Code, Session_Number

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	2	31.9653	15.9826	22.00	0.000
Assessor_Code	7	13.0588	1.8655	2.57	0.022
Session_Number	2	0.0969	0.0485	0.07	0.936
Error	60	43.5889	0.7265		
Total	71	88.7099			

General Linear Model: AP-_Brown_colour versus Sample_Name, Assessor_Code, Session_Number

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	2	42.947	21.4735	19.48	0.000
Assessor_Code	7	5.915	0.8450	0.77	0.617
Session_Number	2	1.135	0.5676	0.52	0.600
Error	60	66.129	1.1021		
Total	71	116.126			

General Linear Model: AP-_Milky versus Sample_Name, Assessor_Code, Session_Number

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	2	327.545	163.773	185.07	0.000

Assessor_Code	7	7.518	1.074	1.21	0.310
Session_Number	2	2.614	1.307	1.48	0.236
Error	60	53.096	0.885		
Total	71	390.773			

General Linear Model: FL-_Sweet versus Sample_Name, Assessor_Code, Session_Number

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	2	16.5453	8.2726	50.24	0.000
Assessor_Code	7	11.6956	1.6708	10.15	0.000
Session_Number	2	0.2969	0.1485	0.90	0.411
Error	60	9.8800	0.1647		
Total	71	38.4178			

General Linear Model: FL-_Milky_(Powde versus Sample_Name, Assessor_Code, Session_Number

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	2	20.2786	10.1393	61.40	0.000
Assessor_Code	7	25.7422	3.6775	22.27	0.000
Session_Number	2	0.2153	0.1076	0.65	0.525
Error	60	9.9083	0.1651		
Total	71	56.1444			

General Linear Model: FL-_Chocolate_ versus Sample_Name, Assessor_Code, Session_Number

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	2	57.6044	28.8022	89.39	0.000
Assessor_Code	7	3.5839	0.5120	1.59	0.156
Session_Number	2	0.6178	0.3089	0.96	0.389
Error	60	19.3333	0.3222		
Total	71	81.1394			

General Linear Model: FL-Bitter versus Sample_Name, Assessor_Code, Session_Number

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	2	140.422	70.2112	503.64	0.000
Assessor_Code	7	3.441	0.4916	3.53	0.003
Session_Number	2	0.011	0.0054	0.04	0.962
Error	60	8.364	0.1394		
Total	71	152.239			

General Linear Model: MF-_Prickly versus Sample_Name, Assessor_Code, Session_Number

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	2	101.047	50.5235	58.30	0.000
Assessor_Code	7	8.964	1.2806	1.48	0.193
Session_Number	2	0.034	0.0168	0.02	0.981
Error	60	51.995	0.8666		
Total	71	162.040			

General Linear Model: AF-_Sweet_ versus Sample_Name, Assessor_Code, Session_Number

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	2	2.8344	1.4172	4.16	0.020
Assessor_Code	7	33.4243	4.7749	14.02	0.000
Session_Number	2	0.4544	0.2272	0.67	0.517
Error	60	20.4400	0.3407		
Total	71	57.1532			

General Linear Model: AF-_Chocolate_ versus Sample_Name, Assessor_Code, Session_Number

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	2	9.1603	4.5801	15.93	0.000
Assessor_Code	7	26.3261	3.7609	13.08	0.000
Session_Number	2	0.9336	0.4668	1.62	0.206

Error	60	17.2528	0.2875
Total	71	53.6728	

General Linear Model: AF-_Astringent versus Sample_Name, Assessor_Code, Session_Number

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	2	3.348	1.6738	6.69	0.002
Assessor_Code	7	21.905	3.1293	12.52	0.000
Session_Number	2	1.103	0.5517	2.21	0.119
Error	60	15.003	0.2500		
Total	71	41.359			

General Linear Model: AF-_Salivation versus Sample_Name, Assessor_Code, Session_Number

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Sample_Name	2	16.2686	8.1343	29.24	0.000
Assessor_Code	7	7.4644	1.0663	3.83	0.002
Session_Number	2	0.3519	0.1760	0.63	0.535
Error	60	16.6928	0.2782		
Total	71	40.7778			

Comparisons for AR-Milky_(Powdered_milk)

Tukey Pairwise Comparisons: Response = AR-Milky_(Powdered_milk), Term = Sample_Number

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Number	N	Mean	Grouping
3	24	4.12917	A
2	24	1.05000	B
1	24	0.12500	C

Means that do not share a letter are significantly different.

Comparisons for AR-_Chocolate

Tukey Pairwise Comparisons: Response = AR-_Chocolate, Term = Sample_Number

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Number	N	Mean	Grouping
3	24	5.78750	A
2	24	4.72500	B
1	24	4.18333	B

Means that do not share a letter are significantly different.

Comparisons for AP-_Brown_colour

Tukey Pairwise Comparisons: Response = AP-_Brown_colour, Term = Sample_Number

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Number	N	Mean	Grouping
1	24	6.96667	A
2	24	5.91250	B
3	24	5.07917	C

Means that do not share a letter are significantly different.

Comparisons for AP-_Milky

Tukey Pairwise Comparisons: Response = AP-_Milky, Term = Sample_Number

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Number	N	Mean	Grouping
3	24	4.67083	A
1	24	0.30833	B
2	24	0.00000	B

Means that do not share a letter are significantly different.

Comparisons for FL-_Sweet

Tukey Pairwise Comparisons: Response = FL-_Sweet, Term = Sample_Number

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Number	N	Mean	Grouping
2	24	5.23333	A
3	24	5.15417	A
1	24	4.17917	B

Means that do not share a letter are significantly different.

Comparisons for AP-_Milky

Tukey Pairwise Comparisons: Response = AP-_Milky, Term = Sample_Number

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Number	N	Mean	Grouping
3	24	4.67083	A
1	24	0.30833	B
2	24	0.00000	B

Means that do not share a letter are significantly different.

Comparisons for FL-_Sweet

Tukey Pairwise Comparisons: Response = FL-_Sweet, Term = Sample_Number

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Number	N	Mean	Grouping
2	24	5.23333	A
3	24	5.15417	A
1	24	4.17917	B

Means that do not share a letter are significantly different.

Comparisons for FL-_Milky_(Powdered_milk)

Tukey Pairwise Comparisons: Response = FL-_Milky_(Powdered_milk), Term = Sample_Number

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Number	N	Mean	Grouping
3	24	4.28750	A
2	24	4.00000	B
1	24	3.04583	C

Means that do not share a letter are significantly different.

Comparisons for FL-_Chocolate_

Tukey Pairwise Comparisons: Response = FL-_Chocolate_, Term = Sample_Number

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Number	N	Mean	Grouping
3	24	7.24167	A
2	24	5.99167	B
1	24	5.05833	C

Means that do not share a letter are significantly different.

Comparisons for FL-Bitter

Tukey Pairwise Comparisons: Response = FL-Bitter, Term = Sample_Number

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Number	N	Mean	Grouping
1	24	2.9625	A
3	24	0.0000	B
2	24	0.0000	B

Means that do not share a letter are significantly different.

Comparisons for MF-_Prickly

Tukey Pairwise Comparisons: Response = MF-_Prickly, Term = Sample_Number

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Number	N	Mean	Grouping
2	24	2.77917	A
1	24	0.66667	B
3	24	0.00000	C

Means that do not share a letter are significantly different.

Comparisons for AF-_Sweet_

Tukey Pairwise Comparisons: Response = AF-_Sweet_, Term = Sample_Number

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Number	N	Mean	Grouping
3	24	1.69583	A
1	24	1.27917	B
2	24	1.27083	B

Means that do not share a letter are significantly different.

Comparisons for AF-_Chocolate_

Tukey Pairwise Comparisons: Response = AF-_Chocolate_, Term = Sample_Number

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Number	N	Mean	Grouping
2	24	2.17083	A
3	24	1.46667	B
1	24	1.37083	B

Means that do not share a letter are significantly different.

Comparisons for AF-_Astringent

Tukey Pairwise Comparisons: Response = AF-_Astringent, Term = Sample_Number

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Number	N	Mean	Grouping
1	24	1.49167	A
2	24	1.45417	A
3	24	1.01667	B

Means that do not share a letter are significantly different.

Comparisons for AF-_Salivation

Tukey Pairwise Comparisons: Response = AF-_Salivation, Term = Sample_Number

Grouping Information Using the Tukey Method and 95% Confidence

Sample_Number	N	Mean	Grouping
3	24	1.16667	A
1	24	0.16250	B
2	24	0.15417	B

Means that do not share a letter are significantly different.

ASSESSORS' QDA PERFORMANCE SCORE BASED ON ANOVA MODEL

Assessor \Descriptors	Code	Jan01-19	Jan02-19	Jan03-19	Jul19-16	May01-18	May03-18	May06-18	Oct01-17
Discrimination		13	11	4	14	8	12	5	9
Repeatability		14	11	14	14	13	14	14	14
No interaction		6	9	7	6	8	12	9	10
Total		33	31	25	34	29	38	28	33

Ideal value for total is 42

Appendix 4: ANOVA AND TUKEY'S PAIRWISE COMPARISON – TDS INTENSITY SCORES

ANOVA – TDS INTENSITY SCORES (MOUTH FEEL AND FLAVOUR)

	MF_Melty	MF_Prickly	MF_Runny	FL_Bitter	FL_Chocolate	FL_Milky	FL_Sweet
Liquid	0.000 b	0.000 b	9.808 a	1.870 b	7.690 a	4.720 a	5.687 a
Slushy	5.035 a	3.654 a	9.817 a	2.387 b	5.587 b	2.352 b	4.317 b
Frozen	4.461 a	4.590 a	9.755 a	5.917 a	4.688 b	0.230 c	3.572 b
Pr > F(Model)	< 0.0001	< 0.0001	< 0.0001	0.000	< 0.0001	< 0.0001	0.000
Significant	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pr > F(Sample)	< 0.0001	< 0.0001	0.448	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Significant	Yes	Yes	No	Yes	Yes	Yes	Yes

ANOVA – TDS INTENSITY SCORES (AFTERTASTE)

	AF_Astringent	AF_Bitter	AF_Chocolate	AF_Salivation	AF_Sweet
Liquid	0.160 b	0.000 c	2.110 a	1.704 a	1.503 a
Slushy	1.468 a	1.184 b	2.006 a	0.000 b	0.228 b
Frozen	1.890 a	1.881 a	1.210 b	0.276 b	0.179 b
Pr > F(Model)	0.003	< 0.0001	0.003	0.000	0.002
Significant	Yes	Yes	Yes	Yes	Yes
Pr > F(Sample)	< 0.0001	< 0.0001	0.001	< 0.0001	< 0.0001
Significant	Yes	Yes	Yes	Yes	Yes

Appendix 5: SURVEY QUESTIONNAIRE

Investigator: Priscilla Ahadzi

Supervisors: Dr. Maame Yaakwaah Adjei

Prof Esther Sakyi-Dawson

Background information:

I am Priscilla Ahadzi, a final year MPhil student from the Department of Nutrition and Food Science, University of Ghana conducting a research to determine a suitable sensory protocol(s) to characterize frozen dairy-based products. This survey is primarily to gather information on how Ghanaians conventionally consume frozen dairy-based desserts packaged in plastic pouches (plastic sachets). The data obtained from the research will help me understand the consumption of these kinds of desserts as well as identify a method for the sensory characterization of these products.

If you consume any frozen dairy products packaged in plastic pouches, please go ahead and take the survey.

This survey should take no more than 5 minutes and I would be very grateful if you can spare a moment to complete this questionnaire.

Note that any personal information as well as data provided will be kept strictly confidential.

Please fill out this questionnaire truthfully and to the best of your ability.

Please circle the appropriate responses.

1. **Please indicate your nationality**
   1= Ghanaian
   2= Other (please specify)……..

Discontinue if non-Ghanaian

2. **Where are you normally resident in Ghana? Town/city and region)**

……
……..

3. **Please select the ethnicity you identify with**

   1= Akan
   2=Ewe
   3=Ga/Adangbe
   5=Guan

6=Northerner
7=Other: Specify ……

4. **Please select your Gender:**
   1=Male 2=Female

5. **Please select your age group:**

   1=10-17 years
   2=18-24years
   3=25-34 years
   4=35-44 years
   5=45-54 years
   6=55-64years
   7=65 years and above

Discontinue if below 18 years

6. **Please select your highest level of education received**

1= None 4= Secondary
2= Primary 5= Tertiary
3= Middle School/JHS 6= Other, specify.....

7. Occupation

Which of the following best describes your current occupation?

1=Student
2=Craftsman/artisan
3=Trader
4=Farmer
5=Stay at home parent
6=Civil servant
7=Health worker
8=Banker
9=Self employed
10=Professional
11= Unemployed
12= Other (specify)…….

8. How often do you consume Frozen dairy products packaged in sachets?
   1= Everyday
   2= At least once a week
   3= Once every two weeks

4= Once a month
5= Less than once a month

9. In what state do you normally consume the aforementioned product?

1= Rock hard solid
2= Slushy
3= Runny
4= Other (please describe)

If Option 1 is selected skip next question

10. If you do not consume it rock solid, how do you melt /thaw/soften/temper the product

1= Allow it to melt on its own till your desired texture
2= Place it in water to quicken the melting process
3= Other (please specify)……
……

11. How do you normally consume the product?

1= Take bites while still hard
2= Crush it before taking bites
3= Suck out the liquid
4= Drink it in the liquid form
5 = pour out the content into a cup or bowl and scoop out or drink
5= Other (please specify) ……

12. On average how long does it take for you to consume one sachet of the frozen dessert? Make your best guess if you have never timed yourself before

1= Less than 5 mins
2= 5-10 mins
3= 10-15 mins
4= 15-20 mins
5= 20-25 mins
6= 25- 30 mins
7= Above 30 mins

13.

	Not at all	**Not really**	**Neutral**	**Somewhat**	**Very much**
To what degree does the physical state of your frozen dessert product influence how much you like it?					

To what degree does the temperature of your frozen product influence how much you like it?					
To what degree does the physical state together with the temperature of your frozen product influence how much you like it?					

14. Would you be willing to come to the Sensory Evaluation Lab – University of Ghana to participate in a 30-minute taste test on frozen dessert

1=Yes
2=No

Discontinue test if selection is No

15. Are you allergic to any of these foods? Tick all that apply.

1= Yoghurt

2= Ice cream

3= Cheese

4= Milk

5= Seafood

6= Gluten

7= Nuts (eg; peanuts)

8= Cabbage

9= None

10= Other, Specify……
….

Discontinue if dairy-based products are selected.

16. The last time you consumed any dairy product (e.g. yoghurt, ice-cream, milk) which of the following symptoms did you notice (tick all that apply to you)?

1= Bloated stomach

2= Stomach aches/cramps

3= Diarrhoea

4= Flatulence (excess gas)

5= Vomiting

6= Nausea

7= Unusual frequency of burping

8= Nothing unusual happened to me

Discontinue if option 8 is not selected

Please provide the following details so you can be contacted to schedule the time for the taste test. The session will be relaxed and informal and you will find it interesting. Your rights as a participant is protected by ethical clearance obtained from the Ethics Committee for Basic and Applied Sciences, College of Basic and Applied Sciences, University of Ghana.

17. Could you please provide us with the following details?

NAME:
…….

CONTACT NUMBER:
……

EMAIL ADDRESS:
…….

Thank you for making time to answer these questions.

Appendix 6: CONSENT FORM

Project Title: CONSUMER ACCEPTANCE OF POLYETHYLENE PACKAGED FROZEN DAIRY-BASED PRODUCTS

Principal Investigator:

Priscilla Ahadzi

Sensory Supervisor:

Dr. Maame Yaakwaah Blay Adjei

Address:

Sensory Evaluation Laboratory, Department of Nutrition and Food Science, School of Biological Sciences, College of Basic and Applied Science, University of Ghana, Legon, Accra.

General Information about Research

You have been invited to partake in a food taste test involving frozen chocolate flavoured dairy-based dessert. During the test, you will be presented with the product at different states to taste and rate your liking on a scale. This activity involves the use of all of your basic senses to evaluate and assess how much you like or dislike the samples served to you. Food taste test is an individual work activity and will involve no discussion with other participants on how you feel about the foods we present to you. In any instance, the researcher will provide you with further details on the test you are to perform and the assessment protocol you should use. There will be a video recording for observational purposes. You may not be aware that you are being videoed. You are entreated to behave as you normally do and not be distracted by the recording.

Possible Risks and Discomforts

In general, this consumer acceptance test, like other food taste tests, is non-invasive and should not be a source of risk to your health or person. The foods you have to taste are all normal foods or the ingredients used to make normal foods. Unless you are allergic or sensitive to dairy milk products or cocoa, this test should not pose a risk to you. The products are handled hygienically and are safe for consumption. If you feel uncomfortable at any point, please call the attention of the researcher who will be able to help you.

Possible Benefits

By participating in the food taste test, you are contributing immensely to consumer consumption style of frozen dairy-based product packed in plastic pouches. This is a huge emotional benefit to you as you will have contributed significantly to evaluation of products in that food category.

Confidentiality

The data you provide to us will be kept confidential by the research team. You will never be personally identified in any work published as a result of your participation in any taste test without your prior consent. We will protect your personal information and not hand this to any third party. Unless you give us permission to contact you again for any sensory work we carry out at the Department of Nutrition and Food Science, we will not keep your contact information after the end of the research project. If you allow us to contact you again, we will only keep your contact details for the purpose of contacting you for sensory studies only and will not give your contact information to any third party. Your details will be kept in a secure file with the sensory research team.

Compensation

You shall receive my gratitude for your time spent on the test. You should understand that there is no economic benefit to you for participating in this sensory study, only the emotional benefit of knowing that you have contributed significantly to the evaluations of frozen dairy-based desserts. This benefit cannot be overlooked.

Additional Cost

There is no additional cost to you for participating in this sensory study organized by the Department of Nutrition and Food Science.

Voluntary Participation and Right to Leave the Research

Although we would like you to complete the study, you should know that your participation is purely voluntary and you have the right to withdraw from the study without giving us any explanation and without any penalty to you.

Your withdrawal from the study will not negatively affect your personal relationship with the investigator, the department or the university as a whole.

Termination of Participation by the Researcher

It is possible that for some tests you sign up to participate in, some exclusion criteria will exempt you from participating. You will be notified of such studies at the onset. If in the middle of a test the investigator realizes that you are not capable of completing a test the investigator may ask you to discontinue the test. This does not have any negative consequence on your relationship with the investigator, the department or the university. You should understand that such decisions are made purely on the basis of preserving the scientific quality of the data we collect from our volunteering participants and have no personal bias to you.

Notification of Significant New Findings

To preserve the scientific quality of the data we collect in sensory testing, we are unable to disclose too much information about the products we test at the onset of the project. However, if your interest in the product is raised through your participation in the project, we can provide additional information about the product to you at the end of the project. You will have to leave your details with the investigator to share such information about the product with you at the end of the study.

Contacts for Additional Information

For information and questions about this study and general sensory tests and protocols at the Department of Nutrition and Food Science at the University of Ghana, please contact:

Dr. Maame Yaakwaah Blay Adjei,

Department of Nutrition and Food Science,

University of Ghana

Email: myblay@ug.edu.gh

Tel: 0545525974

Your rights as a Participant

This research has been reviewed and approved by the Ethics Committee for Basic and Applied Science (ECBAS).

If you have any questions about your rights as a research participant, you can contact the ECBAS Office through the address below

Administrator, Ethics Committee for Basic and Applied Sciences
College of Basic and Applied Sciences
University of Ghana
P. O. Box LG 68
Legon – Accra
Tel: +233244692728
Email: saddo@staff.ug.edu.gh / saddo@ug.edu.gh

VOLUNTEER AGREEMENT

The above document describing the benefits, risks and procedures for the sensory evaluation of foods has been read and explained to me. I have been given an opportunity to have any questions about the research answered to my satisfaction. I agree to participate as a volunteer.

_____ _____

_

Date Name and signature or mark of volunteer

If volunteers cannot read the form themselves, a witness must sign here:

I was present while the benefits, risks and procedures were read to the volunteer. All questions were answered and the volunteer has agreed to take part in the research.

_____
_____

Date Name and signature of witness

I certify that the nature and purpose, the potential benefits, and possible risks associated with participating in this research have been explained to the above individual.

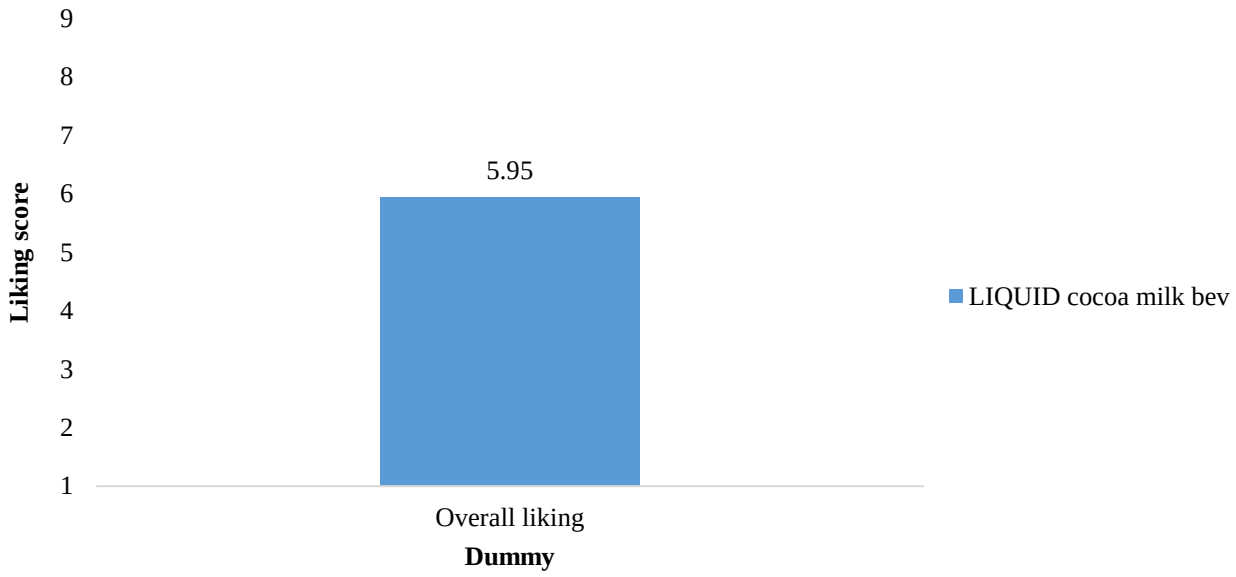
_____ _____

Date Name and Signature of Person Who Obtained Consent

Appendix 7: LIST OF ATTRIBUTES AND DEFINITIONS OBTAINED FROM PANEL CONSENSUS

MODALITY	ATTRIBUTE	DEFINITION	ANCHOR
APPEARANCE	Brown colour	Brown colour	Light to Dark
	Milky	Product appearing to contain milk	Not to Very
AROMA	Milky	Characteristic aroma of reconstituted powdered milk	Not to Very
	Chocolate	Characteristic chocolate aroma of frozen chocolate drink (Ref. Fanchoco chocolate flavoured milk drink)	Not to Very
FLAVOUR	Sweet	Basic taste	Not to Very
	Bitter	Basic taste	Not to Very
	Milky	Characteristic flavour of reconstituted powdered milk	Not to Very
	Chocolate	Characteristic chocolate flavour of frozen chocolate drink (Ref. Fanchoco chocolate flavoured milk drink)	Not to Very
MOUTH FEEL	Melty	Process of changing from solid to liquid due to the presence of heat	Not to Very
	Prickly	Causing a prickling sensation in the mouth due to the presence of ice crystals	Not to Very
	Runny	Free flowing like liquid	Thick to Runny
AFTERTASTE	Sweet	Basic taste	Not to Very
	Bitter	Basic taste	Not to Very
	Astringent	Dry sensation in the mouth	Not to Very
	Chocolate	Lingering chocolate flavour	Not to Very
	Salivation	Triggering production of saliva in the mouth	Not to Very

Appendix 8: MEAN LIKING SCORE OF DUMMY SAMPLE



The dummy product received an overall mean liking score of 5.9 out of 9.