INFLUENCE OF CHOCOLATE TEXTURE ON BELGIAN CONSUMER’S EMOTIONS
AND AFFECTIVE RATINGS

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Gent, 23 August 2013

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Ad Majorem Dei Gloriam! Totus tuus, Maria!

JOEL GARCIA JUVINAL
ABSTRACT

Interest and research on the measurement of emotions associated with food are gaining popularity in food sensory research since emotions can offer a decisive and competitive advantage for food companies especially in advertising.

This study aimed to determine the influence of texture on Belgian consumer emotions and their affective or hedonic ratings. This was explored using three commercial brands of chocolates (Cote d’Or, Carrefour and Koetjesreep) by means of instrumental analyses: colorimetry, texture analysis and differential scanning calorimetry (DSC), descriptive sensory analysis by QDA® with a trained panel (n=8), consumer acceptance testing and emotion testing by the EsSense Profile™ methodology using a consumer panel (n=126).

Results revealed significant differences of the chocolate samples in terms of instrumental and sensory characteristics especially in terms of textural characteristics. Cote d’Or was found to be the hardest both in the instrumental hardness test and Quantitative Descriptive Analysis® while Koetjesreep is the softest. QDA® also showed that Cote d’Or is most intense in brown color, cocoa aroma, snap, hardness, bitterness, creaminess and oily film formation among the three samples which is the opposite of Koetjesreep and had intense grittiness and amount of residuals.

Consumer testing showed that Cote d’Or was the most acceptable sample, followed by Carrefour and Koetjesreep. The EsSense Profile™ methodology for emotion testing revealed that each type of chocolate had a distinct emotional profile. Furthermore, investigating the relationship of sensory attributes and overall acceptability showed that textural characteristics such as harness, snap, oily-film formation were positive drivers of liking while grittiness and residuals influenced overall acceptability in a negative way. More insight was provided by the emotions where Cote d’Or was associated with the most number of positive emotions such as ‘eager’, ‘energetic’, ‘enthusiastic’, ‘free’, ‘glad’, ‘happy’, ‘joyful’, ‘pleased’, ‘satisfied’, and ‘whole’, most of which were significantly different from the other samples. Daring (an unclassified emotion) was associated with Cote d’Or. Carrefour obtained less number of positive emotions and was associated also with the negative emotion ‘disgusted’. Koetjesreep on the other hand was associated with most of the negative emotions (bored, ‘disgusted’ and worried) but was the only chocolate associated with the ‘nostalgic’ emotion.

As such, the overall acceptability and emotional profiles of chocolates in this study are influenced by textural characteristics. However, since differences in other sensory characteristics like color, aroma and taste were also established, the overall acceptability and emotional profile of the chocolates cannot be solely attributed to the influence of texture since food perception is a multi-modal experience. Nonetheless, this study is already one step in exploring how sensory characteristics, overall acceptability and the emotional responses are interrelated which, if harnessed effectively, can offer many interesting insights and be used for competitive marketing in the chocolate industry.
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<td>Analysis of variance</td>
</tr>
<tr>
<td>ASTM</td>
<td>American Society of Testing Materials</td>
</tr>
<tr>
<td>CATA</td>
<td>Check -all-that-apply</td>
</tr>
<tr>
<td>CHOPRABISCO</td>
<td>Royal Belgian Association of the Biscuit, Chocolate, Pralines and Confectionary</td>
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<td>CA</td>
<td>Correspondence Analysis</td>
</tr>
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<td>CAOBISCO</td>
<td>Chocolate, biscuits &amp; confectionery of Europe</td>
</tr>
<tr>
<td>CD CATA</td>
<td>Consumer-defined check -all-that-apply</td>
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<tr>
<td>CLT</td>
<td>Central Location Test</td>
</tr>
<tr>
<td>CRD</td>
<td>Completely randomized design</td>
</tr>
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<td>EU</td>
<td>European Union</td>
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<tr>
<td>DSC</td>
<td>Differential scanning calorimetry</td>
</tr>
<tr>
<td>FBE</td>
<td>Faculty of Bioscience Engineering</td>
</tr>
<tr>
<td>IFST</td>
<td>Institute of Food Science and Technology</td>
</tr>
<tr>
<td>JAR</td>
<td>Just about right</td>
</tr>
<tr>
<td>MAACL</td>
<td>Multiple Affect Adjective Check List</td>
</tr>
<tr>
<td>POMS</td>
<td>Profile of Mood States</td>
</tr>
<tr>
<td>PLSR</td>
<td>Partial Least Square Regression</td>
</tr>
<tr>
<td>QDA®</td>
<td>Quantitative Descriptive Analysis</td>
</tr>
<tr>
<td>UGent</td>
<td>Ghent University</td>
</tr>
<tr>
<td>USA</td>
<td>United States of America</td>
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INTRODUCTION

Recently, the interest and research on the measurement of emotions associated with food are gaining popularity in food sensory research (King et al., 2013; Jaeger, Cardello and Schutz, 2013). Ng, Chaya and Hort (2013) demonstrated that data on acceptability may not be comprehensive of the insights that can be gained from a product. Emotional quality of the product is often a latent aspect that can be used as an advantage in marketing and to influence purchase decision. These authors have shown how emotional measures go beyond liking and offer a decisive and competitive advantage for food companies. Emotion is one of the conceptual categories we associate with food along with functional and abstract concepts (Thomson, Crocker and Marketo, 2010). Moreover, emotions whether positive or negative have an influence on food intake (Greeno and Wing, 1994; Evers et al., 2013).

Although the efforts to develop a widely acceptable definition for emotion have been futile (Panksepp, 2003), an emotion was defined by Bagozzi, Gopinath, and Nyer (1999) as ‘a mental state of readiness that arises from cognitive appraisals of events or thoughts; has a phenomenological tone; is accompanied by physiological processes’ and by King and Meiselman (2010) ‘as a brief, intense (feeling) and often focused on a referent’ and Damaso (2006) as emotion being ‘in the loop of reason’ which guides thought and deeds.

Recognizing the importance of understanding consumer emotion related to food products, a practical approach and innovation in Consumer Research and Sensory Science was launched. One of the most recent methodology is the EsSense Profile™, published in 2010 (King and Meiselman, 2013) which was designed to measure emotions associated with foods, and more generally, on how to measure emotions in a product development context.

The EsSense Profile™ uses traditional consumer test methodology and incorporates the measurement of emotions in conjunction with hedonic questions as part of the test questionnaire. The method requires minimal changes to a sensory test protocol, making it easy to execute in the lab as well as easy for the respondent (King and others, 2010). This method was developed after the Profile of Mood States (POMS) which has its roots in American psychology in the 1940s and 1950s and the Multiple Affect Adjective Check List (MAACL), which is also used extensively in clinical psychiatric settings. However, these existing questionnaires, which largely come from clinical psychiatry do not fill the gap for consumer emotion test in a commercial setting (King, Meiselman and Carr, 2013).
Albeit the relative novelty of the EsSense Profile™, it has already been used by some scientists in different studies and were recently published in international peer-reviewed journals (Jaeger, Cardello and Schutz, 2013; Ng, Chaya and Hort, 2013; Jaeger and Hedderley, 2013). However, its application to chocolate is yet to be investigated. Nonetheless, Thomson, Crocker and Marketo (2010) linked emotions associated the sensory characteristics of dark chocolates using a consumer-generated emotion list quite similar to the EsSense Profile™ but with fewer emotions.

Cocoa products and chocolate are consumed throughout the world, as they provide instant enjoyment and pleasure. Chocolate is one of the most popular examples of foods consumed during comfort eating (Paoletti and others, 2012) and increased activation, reduced tiredness, elevated mood and elicited joy associated with sensory pleasure (Macht and Dettmer, 2006).

Furthermore, it is accepted that chocolate has a hedonic appeal to most people based on sight, colour, preparation, memories of past chocolate experiences, texture and taste. Yet many people are attracted to chocolate for other reasons, frequently suggesting that it settles stress, anxiety and depression. In essence, it can be said that it also has a beneficial impact on mood (Paoletti and others, 2012).

Chocolate quality according to Jovanovic and Pajin (2002) depends on structure, processing techniques and ingredient composition largely that influence the physical properties and sensory perception of chocolate. From among the different sensorial attributes, texture is a very important character of food which for some people even more important than taste (IFST, 2013), although Afoakwa (2009) mentioned that flavour is the most important factor that determines the acceptance and preference for chocolate products. Meanwhile, a descriptive study on milk chocolates showed that there were only few aroma descriptors and that taste and texture in the mouth were the most significant sensory categories for this product (Durcrschmid, Albrecht, Schleining and Kneilfel, 2006). To enhance chocolate texture, solid particle size distribution and ingredient composition are manipulated to modify the physical properties, rheological behaviour and sensorial attributes (Afoakwa and others, 2007). Its effect on acceptability and emotion has not yet been greatly studied.

Thus, understanding the influence of texture of chocolate and its impact not only on general acceptability but also on the emotions that it evokes from the consumer is of paramount importance. A company can use emotions to differentiate themselves from other competing brands, as well as to strengthen their own brand message (Thomson and others, 2010). This can be a bridge for the food or sensory scientist and the marketer to work synergistically to gather actionable product insights and craft a better positioning for the product in the ever-changing global market.
This study aimed to answer the following objectives:

1. To determine the physical characteristics of selected brands of chocolates through instrumental measurements such as Differential Scanning Calorimetry, penetration test and colorimetry
2. To determine the sensory profile of chocolate samples using Quantitative Descriptive Analysis®
3. To determine the emotions associated with different kinds of chocolate using the EsSense Profile® Methodology
4. To correlate overall acceptability and emotion responses from consumers to determine how emotion data provide insight in conjunction with that obtained from affective response

Research framework and hypotheses

The overall objective of the present study is to examine the influence of the texture of chocolate on Belgian consumers’ emotions and affective ratings (e.g. overall acceptability and attribute liking of chocolate). The following specific hypotheses are made:

Differences of samples based on instrumental texture and descriptive sensory analysis

Lawless and Heymann (2010) mentioned that instruments cannot replace sensory evaluation for many important product characteristics. However, correlation analyses are usually invoked to demonstrate that some specific sensory attribute was related to a physical level of an ingredient/treatment, or an objective instrumental measure (Moskowitz, Beckley and Resurreccion, 2006). It is important to establish that samples are different before hedonic testing because according to Meilgaard et al (1999), if there is no product difference, it follows that there is also no difference in acceptability or preference. Both sensory evaluation techniques and instrumental measurements are used in food texture research to assess texture parameters (Meullenet, Lyon and Carpenter, 1998). These authors showed that there was high linear correlation between sensory and instrumental Texture Profile Analysis parameters for hardness (r = 0.76) in their evaluation of twenty-one food samples from a wide variety of food materials. Correlations are generally used to assess the relationship between the instrumental measurement and sensory perception in order to predict consumer responses or to evaluate quality control tools or parameters (Szczesniak 1987). In this regard, since different brands of chocolates were used in this study, it is possible to hypothesize that
they also differ in sensory characteristics (e.g. texture) and this can be shown in instrumental and descriptive sensory analysis.

**Hypothesis 1:** Chocolates used in this study have different sensory characteristics based on instrumental and descriptive sensory analysis

**Link between overall acceptability of chocolate and sensory characteristics**

In a descriptive study on milk chocolates, Durcrschmid, Albrecht, Schleining and Kneilfel (2006) found that there were only few aroma descriptors but it showed that taste and texture in the mouth were the most significant sensory categories for milk chocolate. On the other hand, Torres-Moreno and others (2012) concluded that acceptance for dark chocolates depended not only on the brand or type of chocolate but mostly on the sensory characteristics of the products. Consumers base their overall liking through their perception of the sensory characteristics of food products and sensory properties of food are among the most important factors in consumer food choice (Torres-Moreno and others, 2012). Afoakwa (2010) explicitly noted that texture plays an important role in the sensory assessment of chocolate. In line with these findings, the second hypothesis explores how sensory characteristics affect the overall acceptability of the chocolate samples.

**Hypothesis 2:** Overall acceptability of chocolate samples used in this study is influenced by differences in sensory characteristics

**Emotion profiles of chocolate samples as influenced by texture**

One important purpose of branding as a marketing technique is to establish recognition and positive associations with a company, product name or logo (Connor, 2006). According to Thomson and others (2010) a company can use emotions to differentiate themselves from other competing brands, as well as to strengthen their own brand message. They have also linked the sensory characteristics of dark chocolate with emotions where they found that the taste of cocoa was associated with “powerful” and “energetic” (Thomson and others, 2010). On the other hand, Parker, Parker and Brotchie (2006) reported that chocolate is associated with joy, pleasure and a potential stimulant, relaxant, euphoriant and antidepressant. It also affects negative moods (Macht and Muller, 2007). This may also influence the overall acceptability of chocolate because of the potential effect it has on emotions. On the other hand, numerous gender effects on EsSense Profile responses were established in different food products, but not yet on chocolate (Jaeger and Hedderley, 2013;
King and Meiselmann, 2010). In line with this, it can be hypothesized that differences in sensory characteristics such as texture can influence the consumer’s emotion responses.

**Hypothesis 3:** Chocolates with different sensory/textural characteristics have different emotion profiles.

**Relationship between emotion profiles of chocolate and overall acceptability**

Linking food products to positive emotions is one of the most frequently used marketing strategies for television advertisements (Perez-Salgado, Rivera-Marquez and Ortiz-Hernandez, 2010). Recently published researches on different food products have shown that the measurement of emotions can be used to explore differences when the acceptability or preferences for the products are similar (King and Meiselmann, 2010; Ng, Chaya and Hort, 2013). Currently, there are not many publications that look into the relationship between the overall acceptability and the emotion profile of a product. This hypothesis explores whether consumers associate different emotions with the overall acceptability each chocolate used in this study.

**Hypothesis 4:** The emotion profile of a chocolate can also be related to the overall acceptability.

**Research Framework**

Instrumental Analysis
(e.g. hardness)  \(\leftrightarrow\)  Descriptive Sensory Analysis by QDA®

Consumer Acceptance Testing  \(n=126\)

Essense Profile™ Methodology for emotions
REVIEW OF RELATED LITERATURE

1. Chocolate

1.1 Background/ Technical definition

Chocolate is a complex multiphase system of dispersed solid phase (sugar, cocoa, certain milk components) and continuous phase (cocoa butter, milk fat and emulsifiers) (El-kalyoubi and others, 2011). The proportions of these ingredients result in different types of chocolate. According to Afoakwa (2007), the primary chocolate categories are dark, milk and white that differ in content of cocoa solid, milk fat and cocoa butter. The different chocolates give varying proportions of carbohydrate, fat and protein (Table 1). Cocoa solids are derived from beans obtained from the fruit of *Theobroma cacao*, with world production dominated by Forastero types. (Afoakwa, 2010). Based on European legislation (Directive 2000/36/EC) maximum 5% other fats (e.g. palm kernel oil, shea butter, mango kernel oil) may be used beside cocoa butter.

Beckett (2000) who made extensive studies about chocolate noted that chocolate is unique as a food product in such a way that it is solid at normal room temperatures and yet it melts easily within the mouth. The reason is that cocoa butter is mainly solid at temperatures below 25 °C and thus holds all the solid sugar and cocoa particles together. However, the fat is almost liquid at body temperature (37 °C), which enables the particles to flow past each other, so the chocolate becomes a smooth liquid when it is placed in the mouth.

Table 1. Dark, milk and white chocolate: major constituents.

<table>
<thead>
<tr>
<th>Product</th>
<th>Carbohydrate (%)</th>
<th>Fat (%)</th>
<th>Protein (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark chocolate</td>
<td>63.5</td>
<td>28.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Milk chocolate</td>
<td>56.9</td>
<td>30.7</td>
<td>7.7</td>
</tr>
<tr>
<td>White chocolate</td>
<td>58.3</td>
<td>30.9</td>
<td>8.0</td>
</tr>
</tbody>
</table>

*Source: Afoakwa et al. (2007a)*

1.2 Production and Consumption

Chocolate became increasingly popular in the eighteenth century, but continued to come to Europe from one source: Spanish and Portuguese colonies in South America. In the nineteenth century, this dynamic changed. Chocolate began to be grown, manufactured and produced in new
locations, places to which the chocolate tree, *Theobroma cacao* was neither botanically nor culturally native (Moss and Badenoch, 2009).

Consumption of chocolate rose very quickly, but became more constant over the last ten years with an average of about 8 kg/person per annum of chocolate confectionery being eaten in many Western European Countries. This makes the confectionery industry a very important one. The combined sales of sugar and chocolate confectionery in the UK are more than those of tea, newspapers and bread put together. (Beckett, 2000).

Figures for consumption of chocolate products in 2011 based on the 2012 Caobisco Statistical Bulletin revealed Switzerland as the leader in chocolate consumption at 10.5 kg/person followed by Germany at 9.5 kg/person, United Kingdom (9.45 kg/person). Belgium is on the 8th spot with 7.3 kg/person of chocolate confectionary consumption. Per capita consumption levels tend to be highest in the more northerly European countries or those with a strong chocolate heritage (Afoakwa, 2010).

The Royal Belgian Association of the Biscuit, Chocolate, Pralines and Confectionary (Choprabisco) in 2010 reports that the Belgian sector for Biscuit, Chocolate, Pralines and Confectionary includes 350 companies, 10,408 employments and a turnover of 5.3 billion euro. The market in consumer value amounts 1.6 billion euro, with a turnover of 4.1 billion € (chocolate & pralines included) and production of 56.340 tonnes. Among the different branches of the Belgian food industry, the Biscuit, Chocolate, Pralines and Confectionary branch represents 13.2% of its global turnover.

According to the London-based International Cocoa Organization’s 2012 executive report, consumption of chocolate confectionery products increased by 10% between 2002 and 2010 in selected countries, including the major European countries, the United States, Brazil, Japan and Australia, corresponding to an annual growth rate of 1.2%. This manifests the dip in chocolate consumption in most of the selected countries in 2009, at the height of the global economic crisis. Nevertheless, consumption soon gathered momentum in 2010, increasing by 2.8%, to reach a record level of around 5.54 million tonnes.

1.3 Sensory Perception of Chocolate

Chocolate, according to Afoakwa and others (2007) is a luxury food that during consumption evokes a range of stimuli that activate pleasure centers of the human brain. Central to chocolate quality is an appropriate melting behaviour so that products are solid at ambient temperature and on ingestion melt to undergo dissolution in oral saliva, with a final assessment of texture after phase
inversion. During the production, refining and conching determine particle size, suspension consistency and viscosity, to yield specific textural and sensory qualities (Afoakwa et al., 2008a).

As chocolate melts in the mouth, the continuous fat phase inverts into the oral continuous aqueous phase mixing with saliva that dissolves the sugar particles. Lipids and cocoa solids coat the oral epithelial surfaces. Oral particle dissolution influences perception of coarseness and solvation at rates corresponding to size and work input such as mastication, tongue compression and swallowing (Lee & Pangborn, 1986 as cited by Afoakwa, 2010). Particle size distribution and ingredient composition therefore influence perception of taste and oral volatiles, released with retronasal flavour characters in magnitude and temporal profile (Afoakwa, 2010).

Thamke (2009) reported that through combined data evaluation it was revealed that the easily perceivable chocolate taste descriptors were useful for sample separation (differentiation), whereas flavor descriptors only supported these data. With respect to mouthfeel, chocolate with a lower cocoa content was characterized as melting and creamy, whereas the product with the highest cocoa content was characterized as dry, mealy and sticky. Central to sensory character is continuous phase lipid composition, which influences mouthfeel and melting properties (Afoakwa and others, 2007).

1.4 Texture of Chocolate

Texture is a very important character of food (IFST, 2013). To many people, it is even more important than taste. Food texture has been the focus of many research teams from universities and food companies in the United Kingdom and around the world over the years. Afoakwa and others (2007, 2008, 2008a, 2010), have conducted extensive studies on the rheological and textural properties of the molten dark chocolate. They reported that it showed relatively lower correlation and regression coefficients with melting index, while relatively higher correlation and regression coefficients were noted with hardness. These results explain that hardness (texture) could be effectively used to predict the melting time or duration of finished dark chocolates during consumption. Other processing factors such as tempering, polymorphism and cooling temperature controls could contribute to the variability in hardness and melting index of products.

Moreover, during chocolate production, the crystalline state and the proportion of solid fat present in chocolate are important in determining the melting character in finished products. Differential scanning calorimetry (DSC) has been used to characterize changes in chocolate melting profiles and measures the relative amounts of each crystalline state (Tabouret, 1987; Walter & Cornillon, 2001, 2002; Ziegleder & Schwingshandl, 1998 as cited by Afoakwa, 2010). It also shows the
peaks corresponding to latent heat which are observed in temperature ranges related to melting of specific polymorphs (McFarlane, 1999). Such information is relevant to sensory character and impacts on mechanical and rheological properties of chocolate and confectionery shelf life (Hartel, 2001). In that study DSC was used to characterize the effects of particle size distribution, fat and lecithin content on the crystallization, crystal size distribution and melting profiles of finished dark chocolates (Afoakwa and others, 2008).

Processing techniques, particle size distribution and ingredient composition largely influence the physical properties, rheological behaviour and sensory perception of chocolate. To enhance chocolate texture, solid particle size distribution and ingredient composition can be manipulated to modify the physical properties, rheological behaviour and sensorial attributes. Beckett (2000) pointed out that although, so far, the maximum particle size has been referred to as determining the texture of a chocolate. However, the particle size vary which is best described by a curve, known as a particle size distribution and the chocolate manufacturer has to take a summary of this information to aid with processing and quality control.

On the other hand, the addition of more liquid fat helps a chocolate to flow more easily. Milk fat has the same effect as cocoa butter on viscosity, if added to chocolate at 40°C, but slows down the setting rate and softens the final chocolate. In addition, because milk fat melts at a lower temperature it will change how the product melts in the mouth. The two fats must therefore be present in the right ratio to give the correct chocolate texture in the product in which it is being used (Beckett, 2000).

1.5. Consumer emotions associated with chocolate

Cocoa products and chocolate are consumed throughout the world, as they provide instant enjoyment and pleasure. Chocolate is one of the most popular examples of foods consumed during comfort eating (Paoletti and others, 2012).

Macht and Dettmer (2006) demonstrated that eating chocolate induces both positive and negative emotional changes in healthy, normal-weight women in their natural environment. Chocolate increased activation, reduced tiredness, elevated mood and elicited joy. They also pointed out that this increase of positive emotions was most pronounced 5 and 30 min after eating, thus early mechanisms such as sensory pleasure possibly contribute to a greater extent to emotional effects of chocolate than late mechanisms such as neurochemical changes.

It is accepted that chocolate has a hedonistic appeal to most people; based on vision, color, preparation, memories of past chocolate experiences, texture and taste. Yet many people are
attracted to chocolate for other reasons, frequently suggesting that it settles stress, anxiety and depression. In essence, it also has a beneficial impact on mood (Paoletti and others, 2012).

Affective states appear to be closely linked with chocolate consumption both as antecedents and consequences. Craving, namely an intense desire to eat a particular food, frequently precedes intake of chocolate (Hill & Heaten-Brown, 1994 as cited by Macht and Dettmer (2006)) and has been studied extensively (e.g. Gibson & Desmond, 1999; Michener & Rozin, 1994; Willner et al., 1998). However, the evidence on chocolate’s emotional effects in everyday life is limited.

In an experiment by Thayer (1987) as cited by Macht and Dettmer (2006), they demonstrated increased tension and reduced tiredness 1 h after consumption of a sugar snack, but they did not assess mood or specific emotions such as sadness and joy.

A study revealed that the emotional effects of chocolate are not necessarily positive in overweight persons who felt that they were ‘addicted’ to chocolate and who scored higher than controls on measures related to disordered eating (Macdiarmid & Hetherington, 1995 as cited by Macht and Dettmer (2006). These persons reported a feeling of guilt, but no positive emotions after eating chocolate. It is open to research which positive and negative emotional changes are elicited by eating chocolate in healthy, normal-weight persons in their natural environment.

2. Sensory Evaluation

Sensory evaluation or sensory analysis encompasses a set of techniques to measure human responses to foods in an accurate manner and minimizes the potentially biasing effects of brand identity and other information influences on consumer perception (Lawless and Heymann, 2010). It has been defined as a scientific method used to evoke, measure, analyze, and interpret those responses to products as perceived through the senses of sight, smell, touch, taste, and hearing (Stone and Sidel, 2004).

The field of sensory evaluation can trace one of its origins to the company product expert, whose deep knowledge of a particular product category often served as the guide to quality and new product development. Over the years various researchers involved in product work have involved themselves heavily in the training of panels (Moskowitz, Beckley and Resurreccion, 2006).

However, since its emergence in the 1940s, sensory evaluation has developed as an exciting, dynamic, constantly evolving discipline that is now recognized as a scientific field in its own right (Kemp, Hollowood and Hort, 2009). Sensory evaluation as a discipline of its own grew rapidly in the
second half of the twentieth century, along with the expansion of the processed food and consumer products industries.

Companies have recognized in the past thirty years that the consumer is an important key driver for product success. This recognition has, in turn, generated its own drivers—sensory analysis/evaluation and marketing research, leading first to a culture promoting the expert and evolving into the systematic acquisition of consumer-relevant information. By the early 21st century it was apparent that the field of product testing had matured by developing into a partner with marketing and management (Moskowitz, Beckley and Resurreccion, 2006).

2.1 An Overview of Sensory Evaluation

The principle for all sensory tests is that the test method should be selected on the basis of the objectives for the study. The sensory test design involves not only the selection of an appropriate method but also the selection of appropriate participants and statistical analyses (Lawless and Heymann, 2010).

Drake (2007) explained that sensory evaluation can be categorized into three basic classes or groups of tests: Discriminative, Descriptive and Affective. On the other hand, Kemp, Hollowood and Hort (2009) pointed out that sensory evaluation can be divided into two categories of testing: objective and subjective. In objective testing, the sensory attributes of a product are evaluated by a selected or trained panel. In subjective testing, the reactions of consumers to the sensory properties of products are measured.

For Lawless and Heymann (2010), the three classes of sensory tests can be divided into two types, analytical sensory tests including discrimination and descriptive methods and affective or hedonic tests such as those involved in assessing consumer liking or preferences. The central principle for all sensory evaluation is that the test method should be matched to the objectives of the test (Lawless and Heymann, 2010).

2.2 Classes of Sensory Evaluation Methods

2.2.1. Discriminative Tests

The most widely-used type of analytical sensory test is the discrimination test. The objective of a discrimination test in its simplest and most-used form is to determine if a difference exists between two or more products (Meilgaard et al., 2007). These tests are easy to set up and administer and the results are easily determined using a simple binomial calculation or published tables (Lawless...
and Heymann, 1999). The number of panelists required varies depending on the objectives; generally, 25 to 50 panelists are recommended by Lawless and Heymann (1999).

It is important to remember that the sole purpose of these tests is to determine if a difference exists. Difference tests are one of the most commonly misused sensory tools because the nature of the difference, the degree of difference, or consumer preference cannot be determined using this test nor can these questions be asked of panelists when taking a difference test (Lawless and Heymann, 1999). Difference tests can be set up legitimately in hundreds of different ways, but in practice the procedures described here have acquired individual names and a history of use. According to Meilgaard et al., (2007), there are two groups of difference tests with the following characteristics:

- Overall difference tests which answers the question: “Does a sensory difference exist between samples?”. Examples are Triangle and the Duo-trio test, which are designed to show whether subjects can detect any difference at all between samples.
- Attribute difference tests which answers the question: “How does attribute X differ between samples?”. Subjects are asked to concentrate on a single attribute (or a few attributes), e.g., “Please rank these samples according to sweetness.” All other attributes are ignored. Examples are the paired comparison tests, the n-AFC tests (Alternative Forced Choice), and various types of multiple comparison tests.

2.2.2. Descriptive Tests

The second major class of sensory test methods is those that quantify the perceived intensities of the sensory characteristics of a product. These procedures are known as descriptive analyses (Lawless and Heymann, 2010). Sensory qualities, their intensity and occurrence over time can be measured using this technique. A precise sensory description of a product can be generated and sensory differences between products can be described and quantified (Kemp, Hollowood and Hort, 2009). Descriptive analysis consists of training a group of individuals (generally 6 to 12) to identify and quantify specific sensory attributes or all of the sensory attributes of a food. This sensory tool, unlike the previous analytical tests, which use untrained or instructed/screened individuals, requires training of the panelists. The extent of the training is dependent on the complexity of the sensory attributes that will be profiled. Training may be as brief as a few hours if there are only a few attributes and they are distinct in the samples (Lawless and Heymann, 2010).

Descriptive analysis can be classified into two aspects, qualitative and quantitative. In the qualitative aspect, the sensory parameters of the product are defined by terms such as attributes,
characteristics, character notes, descriptive terms, descriptors, or terminology. These terms define the sensory profile or thumbprint of the sample. The quantitative aspect measures the degree or intensity of the identified characteristics from the qualitative analysis. This measurement is expressed through some value along a measurement scale (Meilgaard, Civille, & Carr, 1991). Like in discriminative tests, these panelists in descriptive analysis would not be asked for their hedonic responses to the products (Lawless and Heymann, 2010).

There are several standard techniques available such as the Flavor Profile Analysis, Texture Profile Analysis, Quantitative Descriptive Analysis (QDA®), and Spectrum Descriptive Analysis (Meilgaard, Civille, & Carr, 1999).

Aside from enhanced product understanding and identification of relationships to instrumental analyses, one of the most important uses of this type of test is to understand consumer perception. Most of the time, the reasons consumers like or prefer a product is not clear unless descriptive analysis is applied to the same set of products. With this tests, the researcher will know the specific sensory or texture profiles of the product; with consumer tests, the products consumers like or prefer are known. For a small number of products or treatments, the sensory profiles of well-liked products can be examined and the researcher can infer why they are liked (Moskowitz, Beckley and Resurreccion, 2006).

### 2.2.3. Affective (Consumer) Tests

The third group of sensory tests is affective or consumer tests. This third major class attempt to quantify the degree of liking or disliking of a product, called hedonic or affective test methods (Drake, 2004; Lawless and Heymann, 2010).

Since consumer tests involve testing with consumers, trained panelists should not be used. Demographic information (age, gender, product usage rate) is generally collected from consumers to determine if these variables influence product liking. Even for small research projects or objectives, a minimum of 50 (Resurreccion, 1998) or 100 (Meilgaard et al., 2007) consumers is recommended to make any conclusion about product liking or preference.

Acceptance testing is also called degree of liking. Consumers are presented with products and asked to indicate degree of liking on a scale. The most commonly used scale is the 9-point hedonic scale. On the other hand, the just-about-right (JAR) scale is another often used scale that is a subcategory of acceptance testing (Lawless and Heymann, 1999). This test is often used in product development or optimization studies because the experimenter can probe if a specific product attribute (such as sweetness or chocolate flavor) is “just about right.” There are a limited number of
categories and only nonparametric statistical analysis is appropriate. Schutz and Cardello (2001) pointed out that the 9-point hedonic scale is a robust and conservative estimate of consumer liking and this scale will certainly continue to be a mainstream quantitative consumer research tool.

2.3. Quantitative Descriptive Analysis® (QDA ®)

The descriptive sensory analysis method used in this study is the Quantitative Descriptive Analysis® (QDA ®). It is based on the principle of a panelist's ability to verbalize perceptions of a product in a reliable manner. In brief, QDA® embodies a formal screening and training procedure, development and use of a sensory language, and the scoring of products on repeated trials to obtain a complete, quantitative description (Hootman, 1992).

2.3.1 Procedure

This method was developed at the Stanford Research Institute by Stone and Sidel (Kemp, Hollowood and Hort, 2009) to provide descriptive data that could be analyzed statistically, in contrast to the methods described previously. It can produce a full qualitative and quantitative sensory description. Panelists or assessors (8–15), are selected for their ability to describe and discriminate products in the category to be studied. They agree on a list of qualitative attributes and then work individually to rate the attributes on a line scale with indented anchors. It is a relative assessment method in that it is not concerned on absolute intensities but on relative intensities between the products (Murray, Delanhunty and Baxter, 2001).

The methods are formalized procedures whereby the panelists can record what they perceive and share these perceptions in a meaningful way with the panel leader and with other panelists similarly trained. The information that the panelists provide when doing descriptive analysis often becomes a “footprint” of the product, used by product development to ensure ongoing quality and to determine whether the development is “on track” (Stone and Sidel, 2004).

At the onset, it was clear that the language used by the subjects would have to be non-technical, everyday language, and that the panel would be responsible for developing it. Use of technical language had other problems- chemical names often have quality connotations; the words also have residual meaning depending on the past experience of the subjects; and the words are not understood by the consumers and are poorly correlated with preference (Stone and Sidel, 1998).

Again, despite the extensive training employed in this method, most researchers assume that judges will use different parts of the scale to make their determinations. Thus, the absolute scale values are not important. It is the relative differences among products that provide valuable
information. The actual product evaluations are performed by each judge individually, usually while seated in isolated booths. Standard sensory practices such as sample coding, booth lighting, expectorating, and rinsing between samples are used for the evaluation phase (Lawless and Heymann, 2010).

Assessments are made in replicates of 2–6 repeat evaluations, data are translated into mean scores and statistically analyzed using ANOVA, individual assessor performance is monitored and compared to that of the panel, and results are presented graphically in spider plots. The attributes are said to be closer to the language a consumer might use. QDA® is a versatile technique that can be used across a range of applications (Kemp, Hollowood and Hort, 2009).

2.3.2. Panelists

According to Lawless and Heymann (2010), panelists are trained to operate in unison as an instrument, and each individual panelist serves a function analogous to an individual sensor on an instrument. Panelist performance should be monitored throughout training to identify problem areas and to track discriminatory ability of the panel. There is no set rule for what constitutes optimal panel or panelist performance. Instead, this is up to the judgment of the panel leader and their knowledge of the panel and panelists as well as the products and attributes. There are different approaches and training techniques for descriptive sensory analysis but the primary goal of these different approaches is the same: a powerful instrument to document sensory properties (Stone and Sidel, 2004). Panelists are selected on their ability to perceive differences between test products and verbalize perceptions (IFT/SED, 1981).

2.3.4 References

The matter of references was considered in developing QDA methodology. References, like any stimuli, are a source of variability and this has to be taken to account when using them. For example, a pure stimulus may be easy to control, but it cannot represent product complexity, whereas using a product reference introduces other sensations unrelated to the test products. In addition, references that are commercial products change on a regular basis for a variety of reasons. For QDA, this dilemma was resolved by offering references only when subjects were experiencing difficulty describing a perception during training. The best references were usually ingredients. Empirically, it was observed that subjects needed references in less than 10% of the panels and usually for fewer than 4 or 5 attributes. The decision to use a reference is made by the panel leader (Stone and Sidel, 1998; Murray, Delanhunty and Baxter, 2001).
2.3.5. Panel Leader Participation

In QDA methodology, the panel leader only served as a facilitator of the process, providing samples, recording what was discussed, and keeping the dialogue focused on the tasks, ensuring that all subjects have equal opportunity to participate, and resolving any conflicts that develop. It was important that the panel leader recognized the impact of non-verbal behavior and remind the subjects that they would be evaluating the products, not the panel leader (Stone and Sidel, 1998).

2.3.6. Quantification

Research has shown that there were number biases in the use of scales, and that the most effective scales were those that had no numbers. Effective use of the scale required practice with the products that would be tested (Stone and Sidel, 1998). To record the intensity for each attribute, panelists make a vertical mark on a 6-in. (152-mm) horizontal line at that point that represents the intensity. The line has two word anchors, placed from each end, and panelists are reminded that they can mark beyond the anchors; for example, marking to the left end of the line would mean that none of that attribute was detected while marking to the right end would mean the strongest intensity for that attribute (Lawless and Heymann, 2010).

2.4 Consumer Testing

The primary purpose of consumer testing is to assess the personal response (preference and/or acceptance) by current or potential customers of a product, a product idea, or specific product characteristics (Meilgaard et al, 1999). The consumer acceptance test is a small panel test usually involving only fifty to a hundred panelists in practice, though Meilgaard, Civille and Carr (1991) strongly recommends that the number of panelists needed for consumer tests should be one hundred. On the other hand, the recommended number of products per sitting is two to five (IFT/SED, 1981).

Consumer acceptance tests focus on the product and are designed for more technical guidance. Overall preference or liking of a product are the main issues addressed by the consumer test, as well as a detailed assessment of the product's sensory properties such as appearance, color, flavor, and texture (Meilgaard, Civille, & Carr, 1991). The 9-point hedonic scale has been used for about fifty years, beginning with acceptance research conducted for the U.S. Army. Such extensive use has brought with it exploration and validation in the scientific literature (Stone & Sidel, 2004).
Lawless and Heymann (1998) stated that consumer acceptance of a food may be defined as (1) an experience, or feature of experience, characterized by a positive attitude toward the food; and/or (2) actual utilization (such as purchase or eating) of food by consumers.

In terms of consumer test locations, the laboratory test allows for the greatest control over the sample preparation and testing conditions, including lighting and environmental conditions. In a sensory laboratory all conditions of the test such as the product preparation and the product evaluation environment can be controlled. This includes control of the testing environment such as lighting, noise, and other distractions, and conduct of the test in individual partitioned booths that isolate panelists from each other (Moskowitz, Beckley and Resurreccion, 2006).

Moreover, in consumer tests by sampling lots of different people the underlying hope is that the test will gather opinions from the different types of mind-sets out in the population, making a study that better represents the array of consumers. However, some authors argue that a sensory testing booth is very different from a real eating environment and the realism of the laboratory test can be questioned (Hersleth et al., 2005). In some studies, laboratory measurements of food preference were shown to be poor predictors of consumption (Cardello et al., 2000; Kozlowska et al., 2003).

Care must be taken that there are not too many panelists in one area since it will encourage inattention or interference. If there are too few technicians to assist the panelists, then panelists’ mistakes or questions that arise during the course of the evaluation may go unnoticed (Resurreccion, 1998). The same author pointed out that with more than twelve people per session, evaluating products using a self-administered questionnaire in an open area under the supervision of one trained technician leads to problems in the session.

It is important to emphasize that the consumer acceptance test is neither a substitute for nor a competitive alternate to the standard large-scale market research test. In other words, consumer acceptance tests should not be used to take the place of large-scale market research tests when the latter are needed; each type of test is conducted by a different functional group within the company and one type of test will not replace the other (Moskowitz, Beckley and Resurreccion, 2006).
3. The EsSense Profile™ methodology

A new breakthrough in Consumer Research and Sensory Science is the field of measuring emotions associated with food. One of the most recent methodology is The EsSense Profile™, presented in 2008 (King & Meiselman) and published in 2010 (King & Meiselman). They reviewed the differences between emotions and moods and the importance of identifying which type of data are being collected.

The EsSense Profile™ measures short and relatively intense responses about consumer products (King and others, 2010). The EsSense Profile™ has been used to guide product development efforts similar to those provided by traditional consumer tests, map a product category, and most importantly, to relate the product to the brand essence, which typically conveys an emotional aspect of the product which is of primary importance to marketing efforts. This new methodology has been applied to different consumer test approaches, such as central location tests, home use tests and internet surveys, all of which have provided useful and actionable data by indicating if any emotions differentiate the test products, and if so, which emotions are stronger or weaker for each particular sample. These data can then be compared to the brand essence or positioning as well as consumer expectations from the product and/or brand (King and others, 2010).

As such, the EsSense Profile™ methodology provides substantial information to traditional consumer tests and overall acceptability data and helps connect Marketing with Product Development efforts via Consumer emotions and Acceptability ratings.

3.1. Advantages of the EsSense Profile™

The EsSense Profile™ uses traditional consumer test methodology and incorporates the measurement of emotions as part of the test questionnaire. The method requires minimal changes to a sensory test protocol, making it easy to execute in the lab as well as easy for the respondent. The EsSense Profile™ is also appropriate for internet use and home use tests (King and others, 2010).

3.2. Approach to the method

This method was developed after the Profile of Mood States (POMS) which has its roots in American psychology in the 1940s and 1950s and the Multiple Affect Adjective Check List (MAACL), which is also used extensively in clinical psychiatric settings. However, these existing questionnaires, which largely come from clinical psychiatry do not fill the gap for consumer emotion test in a commercial setting. Data collection for the EsSense Profile™ is practical in application and requires no additional equipment more than that currently used for consumer testing (paper and pencil or
computerized data entry system). It may include either choose all that apply (CATA) or data scaling (e.g., using a five-point scale). The ballot asks how respondents “feel” while evaluating a stimulus. Stimuli may include a physical product, a concept and/or a name of a product. Products can be branded or not, allowing one to study the effect of branding which has been identified as important in emotion product research (see, e.g., Thomson, Crocker, & Marketo, 2010). Emotion measurements can be taken prior, during and/or after evaluation of the stimulus; however, based on the definition of emotions (King & Meiselman, 2009), the most appropriate time to evaluate emotions is during the exposure to the stimulus, or immediately after, providing an immediate reaction to the product.

### 3.3 Other studies utilizing the EsSense Profile™

Considering the relative newness of this method, there is limited number of published studies that have used it. In a study made by Jaeger, Cardello and Schutz (2013) about participant-centric perspective on “emotion” questionnaires, they compared emotion words generated by free listing and those contained in the EsSense Profile™.

In one part of their study, 40 participants were presented with food names and actual food samples, and asked to write down their emotional responses to these stimuli using a free listing method. These data were compared with EsSense Profile™ responses collected previously for the same stimuli. It was found that participants elicited fewer emotion words than the 39 included on the EsSense Profile™. They concluded that many participants found the EsSense Profile task to be easy and intuitive.

Ng, Chaya and Hort (2013) used the EsSense Profile™ to determine the hedonic and emotional response to commercial blackcurrant squash. They compared the EsSense Profile™ in which respondents rated a predefined emotion lexicon, and check-all-that-apply (CATA) of a consumer defined (CD) lexicon. Their results revealed that both approaches yielded emotional data that clearly discriminated across the products more effectively than the hedonic scores. Equally, EsSense and CD-CATA data produced similar emotional spaces and product configurations although CD-CATA did lack some terms found to be differentiating on the EsSense lexicon.

On the other hand, Jaeger and Hedderley (2013) explored how psychological traits linked to individual differences in perception of emotion affect responses on the 39-item emotion terms on the EsSense Profile by studying emotional intensity and private body consciousness. They found out that the impact on EsSense Profile responses was bigger when data were collected online and in response to food words than in laboratory (CLT) settings when actual foods were tasted. They found out that in laboratory CLT settings fewer effects linked to these traits on EsSense Profile responses...
elicited as participants consumed chocolate and apples. Moreover, numerous gender effects on EsSense Profile responses were established, and it is suggested that aspects of participants’ emotional psychologies be measured if researchers are interested in how emotional responses to consumer products differ between men and women.
3. MATERIALS AND METHODS

3.1 Sample information

Three brands of milk chocolates (premium, store brand and traditional) purchased in local supermarkets (Spar and Carrefour) in the City of Ghent were used in this study. Details on the brand, producer and ingredients from the labels are shown in Table 2. The samples were procured on the same day of each of the experiments conducted in this study.

<table>
<thead>
<tr>
<th>Chocolate brand</th>
<th>Ingredients in the label</th>
<th>Producer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cote d’Or “Lait-Melk”</td>
<td>Suiker, volle melkpoeder, cacaomassa, cacaoboter, weipoeder, emulgator (sojalecithine), magere cacaopoeder, aroma’a, melkvet. Cacao: ten minste 34%</td>
<td>Kraft Foods Belgium, Stationsstraat 100-2800, Mechelen, Belgium</td>
</tr>
<tr>
<td>Carrefour “Lait-Melk”</td>
<td>Suiker, volle melkpoeder, cacaoboter cacaomassa, lactose, emulgator: sojalecithine, aroma. Ten minste 32% cacao bestanddelen</td>
<td>Vervaardig in Belgie door: B00135 voor CMI – 2, avenue du Pacifique 91940 Les Ulis - France</td>
</tr>
<tr>
<td>Koetjes reep* “met druivensuiker en calcium”</td>
<td>Sugar, hydrogenated vegetable fat, lactose, low fat cocoa powder, low fat milk powder, calcium carbonate 3,5%, dextrose 2% emulsifier: soya lecithin; stabilizer: E492; flavours</td>
<td>The Belgian Chocolate Group nv, Geelseweg 72. B-2250 Olen.</td>
</tr>
</tbody>
</table>

*Chocolate flavoured bar

3.2 Instrumental measurements

3.2.1. Color measurement

Color was measured with a handheld Minolta CM2500D Spectrophotometer (Konica Minolta Sensing, Inc. Osaka, Japan) after calibration with white and black glass standards. The color was expressed in the CIELAB coordinates: the lightness L*(0: black to 100: white), a*(negative values indicate green while positive values indicate red) and b*(negative values indicate blue and positive values indicate yellow). Color measurement was done in triplicate in different chocolate bars for the three samples.
3.2.2. Penetration test

Hardness was measured by determining the maximum penetration force for chocolate. A 8942 Texture Analyser (Instron, USA) was used to measure the depth of penetration of samples and maximum load using the following parameters: product height 10 mm, penetration depth 5 mm; temperature 20°C, The needle rate was set at 2 mm/s and detection started when the force reached 0.2 N. The duration time of the test took approximately 1±2 min. The measurements were performed 10 times on different chocolate bars for the three samples.

3.2.3. Determination of melting properties of chocolates

The melting profile of the chocolate samples was determined using the Differential Scanning Calorimetry (DSC) machine (2010, Texas Instruments, Belgium). Samples (10 ±5mg) were cut from the bars using small scalpels and weighed in an analytical balance (model) in DSC pans and hermetically sealed with lids using a sample press. They were sprayed with ethanol to remove fat traces from handling and weighed again. DSC melting curves were recorded at a heating rate of 5°C/min from 22 to 65°C in a N₂ stream. Melting point was obtained from the DSC thermogram. Onset temperature (T_onset), peak temperature (T_peak), end temperature (T_end) and enthalpy of melting (DH_melt) were calculated automatically by the software. Analysis was carried out in triplicate and mean values and standard deviations reported.

3.3 Determination of the sensory profile chocolate

Sensory profiling of chocolates was done using quantitative descriptive analysis (QDA®) according to Stone and Sidel (1993) as cited by Donadini (2012). Descriptive analysis is composed of the following phases: 1) a qualitative, lexicon generation process; and 2) a quantitative set of sensory tests designed to quantify on a rating scale the intensity of the sensory terms established in the lexicon generation phase. Descriptive analysis was performed in the SensoLab of Ghent University in accordance with international standards (Hootman, 1992).
3.3.1 Qualitative phase of QDA

Generation of descriptors and score sheet development

The chocolate-panel (n=8) of the SensoLab of Ghent University were invited for the sensory profiling. Panelists had considerable amount of experience in sensory evaluation of chocolate and chocolate products in previous studies.

Panelists were asked to individually characterize each of the three samples of milk chocolate in terms of appearance, aroma, texture, taste and aftertaste. Sensory attributes/terms that were considered important were noted. After the panelists determined all possible attributes of the samples, similar words were grouped while some words which were antonyms of some terms were deleted from the list. The final terms (n=15) that were retained were integrated into a score sheet and were used for the evaluation. This covers appearance (n=2), aroma (n=4), taste (2) and focused on texture (n=7).

The training of the panelists for the use of the unstructured 15-cm QDA scale was expedited by a training leader or facilitator as suggested by Moskowitz (1988) as cited by de Leon (1993). During the course of the training, the facilitator provided standards and training samples as needed; prepared trial score sheets from the terms; thought of ways to clarify confusion; and tested and monitored the panelist’s performance.

The training facilitator began the training by defining each of the attributes in the trial evaluation form developed by the earlier descriptive panel. After which, some reference samples were served. At this point, the panelists were asked to quantify the intensities of each of the attributes of the milk chocolates using a 15 cm unstructured scale. This step gave a clear identification as to the areas where panelists experienced difficulties and helped solve the problems that emanated from the panel’s use of the descriptors. Also, the panelists were encouraged to voice out questions, opinions and suggestions. Considering the suggestions of the panelists (if any), necessary revisions were made on the score sheet before the final evaluation session. The panelists were asked if they were satisfied with the revisions made and if they were already at ease in using the score sheet. Hence, after the agreement by consensus among the panelists the final form was used for the replicated product sensory evaluation.
3.3.2 Quantitative phase of QDA

*Replicated product evaluation of milk chocolates*

Three brands of milk chocolates (Table 2) were used in the replicated product evaluation. The samples used in the qualitative phase of QDA were the same samples used in this activity. The test was conducted at the SensoLab of Ghent University. Each chocolate tablet was cut into approximately 15-g pieces crosswise 15 min before serving. The samples were equilibrated for 5 min to room temperature (20 ±1 °C) as suggested by Torres-Moreno and others (2012) and served in small disposable plastic plates. Panelists were seated in individual booths under artificial daylight illumination. Samples were coded with a 3-digit random number and were given to the panelists one at a time in a unique randomized order to avoid bias. They were asked to evaluate the samples using the developed score sheet and in terms of the descriptors that were generated during the qualitative phase of the QDA. The intensity of the attributes was scored using a 15 cm scale. To decrease the level of fatigue and to clear their palate, panelists were given still mineral water in plastic cups.

3.4 Consumer Testing and the EsSence Profile™ Methodology

Consumers who served as respondents in this study were randomly recruited at the vicinity of Ghent University (UGent) mostly from the Faculty of Bioscience Engineering (FBE). They were asked to participate through personal invitation, electronic mail, internet social networking and advertisement in the cafeteria of FBE. Some respondents personally volunteered after word-of-mouth information from those who have participated earlier. Eligibility for selection were based on the following criteria as suggested by Meilgaard and others (1999): 1) regular consumers of chocolate 2) do not have a specific disliking for chocolate; 3) do not have any known food allergies or dietary intolerance; 4) willingness and availability to participate in the study. As part of the participant recruitment, information on demographics and patterns of chocolate consumptions were collected via a questionnaire after the chocolate evaluation.

From the approximately 250 people who were invited, 131 of them were able to go to the SensoLab of UGent-FBE to actually participate. Since the testing booths of the SensoLab is limited (n=7), the respondents were scheduled in order to avoid waiting time and crowding. The consumer testing was conducted and completed in a period of about 2 weeks from the middle of May, 2013.

Respondents were seated in individual booths of the SensoLab. They were given a brief instruction about the mechanics of the test. The chocolate samples were given in random order and
were presented monadically in the same manner and condition as in the descriptive analysis following a completely randomized design (CRD). The label of the chocolate samples were removed and were placed up-side down in cardboard with plastic lining with random 3-digit codes before serving to the respondents. The preparation was done in a hygienic manner and in not more than 10 minutes before the evaluation to avoid prolonged exposure to air and environment. The respondents were asked not to turn or look at the chocolate on order to avoid possible brand recognition.

The one-page questionnaire/score sheet (Appendix 1) was composed of three parts. First, they were asked to taste the chocolate and were rate their overall liking for each product, using a nine-point hedonic scale (Lawless and Heymann, 2010). Second, they were asked to indicate their emotional responses using CATA (check all that apply) of the associated consumer-defined lexicon by King and others (2010) in the EsSence Profile™ Methodology. They were instructed to ‘check or tick all the terms that describe how they feel just after consuming the chocolate sample. Lastly, they were asked to indicate in a ‘just about right’ (JAR) scale their perception on the texture of the chocolate. They were given table napkins and were encouraged to drink some still mineral water (Sainte-Sophie, France) in between samples to cleanse their palate and have some rest. The average time for a respondent to complete the evaluation was 10 minutes. Each respondent was given a colored pen as a token for participation since some incentive to participate in a sensory study is usually necessary in order to motivate people to volunteer (Lawless and Heymann, 2010).

3.5 Statistical Analysis

Instrumental Tests

Penetration test data (hardness), colour – lightness (L*), a- and b-values, and peak melting (Tpeak) from DSC were analyzed using analysis of variance (ANOVA) to determine if significant differences exist among samples. When significant differences were found, Tukey HSD post-hoc test was used to determine where the differences occurred. Significance of the differences were defined at p<0.05. Moreover, Kolmogorov-Smirnov test for normality and Modified Levene tests were also performed to check if assumptions related to ANOVA were fulfilled.

QDA® and Overall acceptability

After the evaluation, the results were decoded. Scores marked by the panelists on the rating scales were measured in centimeters from the left to the right end of the scales. Data obtained from each panelist were recorded as a product-attribute matrix. Completely randomized design (CRD) in
treatment factorial design will be employed in the analysis of pooled data wherein panelist was considered as a random factor. Analysis of variance (ANOVA) was used to determine if there were significant differences for: a) sensory attributes across chocolates b) overall liking across chocolates by means of SPSS® statistical package version 19 from Athena server of UGent (SPSS Inc., Chicago, IL, USA). When significant differences were found, Tukey HSD post-hoc test was used to determine where the differences occurred. Significance of the differences were defined at p<0.05.

**Emotions**

A comparison of categorical data for the emotions associated with the different chocolate samples was performed using the Cochran’s Q Test for each emotion in SPSS. Pairwise comparison between the brands for each emotion was done using the McNemar Test in SPSS. Correspondence Analysis (CA) was performed on the average frequency of the 39 emotions for each type of chocolate in order to identify the relationships between the emotion terms and the products as suggested by Ng, Chaya and Hort (2013). To determine the relationship between the overall acceptability and the emotional responses as well as the sensory characteristics of each chocolate sample, Partial Least Square Regression (PLSR) was done on the mean overall liking scores, mean sensory scores and the average frequency data. A landscape segment analysis map is produced for overall acceptability and the sensory characteristics and the overall acceptability and emotional responses that shows the ‘drivers of liking’ or the sensory characteristics and emotions that negatively or positively correlate with overall acceptability (XLSTAT Version 2013.4.05, Addinsoft, USA).
4. RESULTS AND DISCUSSION

4.1 Instrumental measurements

4.1.1. Color measurement

Figure 1 shows the color measurement of chocolate samples measured with a handheld Minolta CM2500D Spectrophotometer (Konica Minolta Sensing, Inc. Osaka, Japan) after calibration with white and black glass standards. Based on the CIELAB coordinates, SCE values are reported: the lightness $L^*$ (0: black to 100: white), $a^*$ (negative values indicate green while positive values indicate red) and $b^*$ (negative values indicate blue and positive values indicate yellow).

Analysis of variance (ANOVA) revealed significant differences among the three samples in all the parameters. Tukey HSD test was used to separate the means. In terms of lightness, the Carrefour brand was significantly lighter ($L=37,01; p<0,05$) than Cote d’Or (33,70) and Koetjesreep (33,30). Since chocolate composition is one of the primary influences on the characteristics of color quality (Full, Reddy, Dimick and Ziegler, 1996), this difference can be attributed to the higher amount of cocoa mass in Cote d’Or based on the label (at least 34 %) than Carrefour (at least 32 %) which produced a darker appearance. Although Koetjesreep did not indicate the amount of cocoa on its label, it is not significantly different ($p<0,05$) from Cote d’Or in terms of lightness. These values correspond to the findings of Popov-Raljić and Laličić-Petronijević (2009) on their study of milk chocolates where they found lightness values that range from 31,50 to 36.

On the other hand, the positive values in the ‘a’ axis denotes that the all samples are closer to the red space rather than the opposite green. Koetjesreep was significantly highest (12,50) in this parameter followed by Carrefour (10,77) and Cote d’Or (9,60) which implies that Koetjesreep appeared to have a more intense red color. The same trend was found for the ‘b’ axis where the positive values of all the samples indicates that samples are in the yellow space rather than blue. Koetjesreep had the highest ‘b’ value (18,59) which was significantly different from Carrefour (13,47) and Cote d’Or. This yellowish appearance may be the reason why Koetjesreep had the lowest brown color score in the Quantitative Descriptive Analysis ® by the trained panel (see part 4,2). This can be attributed to the ingredients in Koetjesreep like cocoa powder instead of cocoa mass and the type of fat in based on the label (hydrogenated vegetable oil) which forms a different crystal network than cocoa butter which according to Afoakwa (2009) scatters light, reducing luminance and saturation indices in higher fat products.
4.1.2. Penetration test for hardness

Hardness was measured by determining the maximum penetration force for chocolate. A 5942 Texture Analyser (Instron, USA) was used to measure the depth of penetration of samples and maximum load in Newton (N) at 20°C at the thickest point. Figure 2 shows the hardness values (N) of the three chocolate samples. ANOVA revealed significant differences (p<0.05) among the three samples. Tukey (HSD) test showed that Cote d'Or was the hardest (8.09 N) followed by Carrefour (7.35 N) and Koetjesreep (5.67 N). This may be primarily due to the differences in the ingredient formulation and manufacturing techniques (Beckett, 1999). Moreover, Liang and Hartel (2004) explained that milk powders with different free milk fat content may be expected to have an influence on chocolate hardness although the exact mechanism for this effect is not clear. Generally, milk chocolates tend to be softer than dark chocolates primarily because the milk fat dilutes the cocoa butter, resulting in a lower solid fat content at any temperature (Liang and Hartel, 2004). Also, Guinard and Mazzucchelli (1999) showed that hardness of chocolate is correlated with sugar and fat levels. On the other hand, Afoakwa et al (2008) found that hardness decreased as particle size increased irrespective of state of temper. However, it should be noted that since commercial chocolates were used, there is a natural difference in the thickness of the chocolates which may also influence the texture measurement.
Figure 2. Hardness measurement (maximum force in Newton) of the three chocolate samples using Instron Texture Analyzer

Means not sharing the same capital letter superscript are significantly different at 5% level of significance based on Tukey’s HSD test.

4.1.3. Determination of melting properties of chocolates

The melting profiles of the three chocolate samples obtained by Differential Scanning Calorimetry is shown in Figure 3. Differences in peak widths are apparent which may reflect variation in melting properties and crystallinity as proposed by McFarlane (1999). Cote d’Or shows a single peak which may indicate that there is only one type of fat (cocoa butter) present in this chocolate. On the other hand, both Koetjesreep and Carrefour shows two peaks (one big and one small) which may suggest the presence of more than one type of fat or fat polymorph present in the chocolate (Beckett, 2000). However, this can also be due to the equilibration of the DSC. For Koetjesreep, this may be due to the fact that there is partial substitution of fat other than cocoa butter that is beyond the maximum allowed by the EU. Thus, in a more technical classification, Koetjesreep is labeled as “chocolate flavored bar”. Such information is relevant for the sensory characteristics and impacts on mechanical and rheological properties of chocolate and confectionery shelf life (Hartel, 2001). Differential Scanning Calorimetry has been used to characterize changes in chocolate melting profiles and measures the relative amounts of each crystalline state (Afoakwa, 2010).
The mean melting temperatures of the chocolate samples are presented in Table 3. Analysis of variance revealed significant differences on the melting temperatures of the chocolate samples. Tukey HSD showed that Koetjesreep had a significantly higher melting temperature than the other two brands. This may be due to the fact that Koetjesreep contains hydrogenated vegetable oil. Hydrogenation reduces double bonds to single bonds, thereby increasing both melting point and stability of the oil and raises the melting temperature (Schmidt et al., 1996). On the other hand, the melting temperatures of Cote d’Or and Carrefour are within the range of melting point as stated by Van Malssen et al (1999) for cocoa butter 29 to 34°C for the βV form.
Table 3. Mean melting temperatures of the chocolate samples.

<table>
<thead>
<tr>
<th>Brand</th>
<th>Melting temperature (°C)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cote d’Or</td>
<td>32.44&lt;sup&gt;A&lt;/sup&gt;</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>Carrefour</td>
<td>32.65&lt;sup&gt;A&lt;/sup&gt;</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Koetjes Reep</td>
<td>33.50&lt;sup&gt;B&lt;/sup&gt;</td>
<td>0.14</td>
<td></td>
</tr>
</tbody>
</table>

<sup>A,B</sup> Means with the same letter superscript in a column are not different at 5% level of significance based on Tukey HSD.

4.2 Determination of the sensory profile chocolate

Quantitative descriptive analysis (QDA) was used to establish a sensory profile for chocolate. It aimed to generate descriptive terms for chocolate and to determine whether these descriptors were discriminators of product difference. The study employed three brands of chocolates: Cote d’Or, Carrefour milk chocolate and Koetjesreep (chocolate-flavored bar).

4.2.1 Qualitative phase of QDA

*Generation of descriptors and score sheet development*

A total of 15 attribute descriptors were used in the QDA score sheet which covers (1) appearance (color and gloss or surface shine), (2) aroma (cocoa, caramel, vanilla, milky aroma), (3) taste (sweetness and bitterness), (4) texture (snap, hardness, graininess/ grittiness, creaminess, rate of melt, presence of oily or greasy film and residual or the amount of solid particles left in the mouth). During the two 2-hour sessions all descriptors were discussed by the panelists, led by a panel leader, and agreement concerning the meaning of terms was obtained. However, two trained panels of the SensoLab were not able to attend this session but were still included in the replicated product evaluation as advised by Stone (1992) because they had several experiences in descriptive analysis of chocolates in the SensoLab researches in the past. The panelists were also familiarized with the use of the unstructured line scale and some of the references before they evaluated the samples. Moreover, three panelists who expressed some difficulties or uncertainties in some of the descriptors were individually coached by the panel leader in a separate session by presenting them some references to clarify confusion as suggested by Moskowitz (1988).

The panelists agreed among themselves that the color of the chocolates assumed a single brown hue which differed in their value (intensity of color; e.g. dark brown) and chroma (dullness or vividness of color; e.g. dull brown). They also agreed on the definition of the different sensory
attributes among themselves (Appendix 2) and they suggested references applicable for the most of the attributes (Appendix 3).

**Replicated product evaluation of milk chocolates**

Analysis of Variance (ANOVA) and Tukey’s HSD test was done to determine whether the 15 descriptors were discriminatory for product difference as suggested by Powers (1988a). If the p-value for a term is not significant at 5% level (p>0.05), the sensory attribute can only be characterized as being a descriptor. If the p-value on the other hand is significant (p≤0.05) at 5% level, then the attribute is discriminatory. This means that the attribute can differentiate one product from another in terms of this attribute.

Results of the replicate product evaluation revealed that 12 out of 15 attribute descriptors used were good discriminators of product difference. This implies that the generated descriptors can distinguish differences in sensory attributes of the chocolate samples based on ANOVA and mean separation technique (Tukey’s HSD test). Moreover, the F-values for interaction between samples and panelists were not significantly different for nearly all the attributes. These results indicated that the mean scores for the chocolate sample given by each panelist for all attributes could be assumed satisfactory estimates of the sensory profile of the different samples.

Table 4 and figure 4 show the mean intensity scores of the chocolate samples on the different sensory attributes evaluated by the trained panel using QDA ®. The panel successfully detected differences among the samples in 12 out of 15 attributes, even though they were presented monadically.
Table 4. Mean intensity scores of the chocolate samples on the different sensory attributes by QDA

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Cote d’Or</th>
<th>Carrefour</th>
<th>Koetjesreep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>9.56&lt;sup&gt;A&lt;/sup&gt;</td>
<td>5.99&lt;sup&gt;B&lt;/sup&gt;</td>
<td>4.41&lt;sup&gt;C&lt;/sup&gt;</td>
</tr>
<tr>
<td>Gloss</td>
<td>9.58&lt;sup&gt;B&lt;/sup&gt;</td>
<td>7.55&lt;sup&gt;C&lt;/sup&gt;</td>
<td>10.68&lt;sup&gt;A&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cocoa aroma</td>
<td>9.14&lt;sup&gt;A&lt;/sup&gt;</td>
<td>7.15&lt;sup&gt;B&lt;/sup&gt;</td>
<td>4.71&lt;sup&gt;C&lt;/sup&gt;</td>
</tr>
<tr>
<td>Caramel aroma</td>
<td>4.53&lt;sup&gt;B&lt;/sup&gt;</td>
<td>5.79&lt;sup&gt;B&lt;/sup&gt;</td>
<td>6.50&lt;sup&gt;A&lt;/sup&gt;</td>
</tr>
<tr>
<td>Vanilla aroma</td>
<td>3.30</td>
<td>4.51</td>
<td>4.58</td>
</tr>
<tr>
<td>Milky aroma</td>
<td>4.61</td>
<td>6.14</td>
<td>6.58</td>
</tr>
<tr>
<td>Snap</td>
<td>9.50&lt;sup&gt;A&lt;/sup&gt;</td>
<td>7.29&lt;sup&gt;AB&lt;/sup&gt;</td>
<td>6.31&lt;sup&gt;C&lt;/sup&gt;</td>
</tr>
<tr>
<td>Hardness</td>
<td>8.73&lt;sup&gt;A&lt;/sup&gt;</td>
<td>7.78&lt;sup&gt;AB&lt;/sup&gt;</td>
<td>4.43&lt;sup&gt;C&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sweetness</td>
<td>8.58</td>
<td>9.79</td>
<td>9.95</td>
</tr>
<tr>
<td>Bitterness</td>
<td>4.68&lt;sup&gt;A&lt;/sup&gt;</td>
<td>1.70&lt;sup&gt;B&lt;/sup&gt;</td>
<td>0.86&lt;sup&gt;B&lt;/sup&gt;</td>
</tr>
<tr>
<td>Grittiness</td>
<td>2.72&lt;sup&gt;B&lt;/sup&gt;</td>
<td>3.24&lt;sup&gt;B&lt;/sup&gt;</td>
<td>8.41&lt;sup&gt;A&lt;/sup&gt;</td>
</tr>
<tr>
<td>Creaminess</td>
<td>9.24&lt;sup&gt;A&lt;/sup&gt;</td>
<td>8.92&lt;sup&gt;A&lt;/sup&gt;</td>
<td>6.25&lt;sup&gt;B&lt;/sup&gt;</td>
</tr>
<tr>
<td>Rate of melt</td>
<td>6.51</td>
<td>7.45</td>
<td>7.57</td>
</tr>
<tr>
<td>Oily film</td>
<td>8.73&lt;sup&gt;A&lt;/sup&gt;</td>
<td>7.82&lt;sup&gt;A&lt;/sup&gt;</td>
<td>4.40&lt;sup&gt;B&lt;/sup&gt;</td>
</tr>
<tr>
<td>Residual</td>
<td>3.20&lt;sup&gt;B&lt;/sup&gt;</td>
<td>3.31&lt;sup&gt;B&lt;/sup&gt;</td>
<td>6.73&lt;sup&gt;A&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>AB</sup> Means within a row not sharing the same capital letter superscript are significantly different at 5% level of significance based on Tukey’s HSD test.

### Appearance

Analysis of variance (ANOVA) showed significant differences (p<0.05) in terms of brown color and gloss. Cote d’Or was significantly more intense (mean score: 9.56) in brown color than Carrefour (5.99) and Koetjesreep was least intense in brown color. This differences can be attributed to the higher amount of cocoa mass in Cote d’Or based on the label (at least 34%) than Carrefour (at least 32%) which produced a darker appearance since chocolate composition is one of the primary influences on the characteristics of color quality (Full, Reddy, Dimick and Ziegler, 1996). However, this result is not coherent with the instrumental color analysis where Koetjesreep did not have the lowest luminance or lightness (L) value. This may be explained by the effect of the differences of surface roughness of the surface which affect the perception of color and gloss (Briones, Aguilera and Brown, 2006).

Conversely, Koetjesreep had the highest mean score for gloss (10.68) which was significantly higher (p<0.05) than the other two samples. Cote d’Or obtained the lowest mean score for gloss. Gloss relates to capacity of a surface to reflect directed light at the specular reflectance angle with respect to the normal surface plane (ASTM, 1995). Beckett (2000) noted tempering was important for gloss, a key quality attribute in chocolate. In under-tempered chocolates light scattering is caused by reductions in surface regularity.
Aroma and taste attributes

In terms of cocoa aroma, Cote d’Or had the highest mean score (9,14) which was significantly different (p≤0,05) from Carrefour and Koetjesreep. Cocoa aroma is a function of the amount of chocolate mass in the formulations (Guinard and Mazzucchelli, 1999) which is in congruence with the information on the labels of the chocolates. Koetjesreep had the highest intensity of caramel aroma (6,50) which was significantly different from the other two samples. Caramel aroma is influenced by the sugar content and to a lesser extent by fat and milk solid levels (Guinard and Mazzucchelli, 1999). All three samples were not significantly different in terms of vanilla and milky aroma and sweetness.

Cote d’Or was rated to have the highest intensity of bitterness (4,68) which was significantly different (p<0,05) from Carrefour and Koetjesreep. These two samples did not differ significantly from each other in terms of bitterness and it should be noted that they had very low intensity of bitterness (1,70 and 0,86, respectively) which is almost absent. The reference standard for bitterness used by the panelists was Everyday™ dark chocolate which may explain the relatively lower bitterness mean scores of the samples. Nevertheless, Cote d’Or was found to be significantly more bitter than the other two samples. Bitterness in chocolate is mainly due to the caffeine and theobromine which are naturally occurring in cocoa beans (Beckket, 2000).

Texture attributes

Cote d’Or obtained the highest mean hardness intensity score (8,73) which was not significantly different from Carrefour (7,78). Koetjesreep was significantly (p<0,05) less hard (mean score: 4,43) than the other two samples. This result complements the instrumental texture analysis for hardness which showed a similar trend. These differences may be primarily due to the differences in the ingredient formulation and manufacturing techniques as suggested by Becket (2000). Hardness is related to forces of attraction between particles of food that oppose disintegration (Munoz et al, 1992) and reaction of the food to applied stress (e.g. by chewing in between the teeth). It is a primary mechanical characteristic that may be defined by the popular terms soft, firm or hard (Szczesniak, 1963).

The same trend was observed for the attribute snap. Cote d’Or had the highest mean intensity of snap (9,50) which was not significantly different from Carrefour (7,29). Koetjesreep had significantly lower (p<0,05) snap mean score (6,31) than the other samples. This may be due to the different fat (hydrogenated vegetable fat) in Koetjesreep. The fat phase has the greatest influence on chocolate properties such as snap and gloss (Beckett, 2009).
On the other hand, Koetjesreep obtained the highest mean score for grittiness (8.41) which was significantly more intense than Carrefour (3.24) and Cote’Or (2.72) which had very low scores. Grittiness or graininess on the other hand is a more common term to describe geometrical characteristics such as particle shape and size. This attribute show the perception of highly organized structures of different geometrical arrangements within the product (Munoz, et al. 1992). This may suggest that the particle size of Koetjesreep may have been greater than 30 µm since grittiness was detected by the panelists (Beckett, 2000).

Creaminess was defined by the panelists as related to the smoothness of the mouth feel of the chocolate as related to fat. Creaminess is linked to milk fat globules in dairy products (Bom Frøst and Janhøj, 2011). Cote d’Or (9.24) and Carrefour (8.92) had significantly higher (p<0.05) intensity of creaminess than Koetjesreep (6.25).

All three samples were not significantly different in terms of rate of melt. This refers to the dynamic (i.e., time-dependent) aspect of food breakdown. The panelists seemed to have some difficulty in evaluating this attribute since the DSC result for melting showed that Koetjesreep had a significantly higher melting temperature than the other two samples. However, the rate of melt can also be influenced by the variation in the size of sample that was consumed by the panelists and the rate of chewing which should be standardized in future studies.

In terms of oily film formation in the mouth Cote d’Or and Carrefour did not differ significantly (p<0.05). Their mean scores (8.73 and 7.82) are significantly higher (p<0.05) than Koetjesreep. Oiliness or greasiness refers to a secondary term to describe fat content in the product (Hootman, 1992). It is one of the sensory properties that correlate most with creaminess irrespective of product type (Bom Frøst and Janhøj, 2011). This can be attributed to the amount and type of fat in the samples.

On the other hand, Koetjesreep had the highest intensity of residuals (mean score: 6.73). It was significantly higher than Cote d’Or (3.20) and Carrefour (3.31). Residuals were defined by the panelists as the amount of solid particles left in the mouth after swallowing. This attribute is somewhat related to grittiness where Koetjesreep also had the highest intensity.
Based on the shape of the spider graph, it was noticeable that the samples are clearly differentiated in most of the attributes but showed nearly similar profiles in terms of vanilla aroma, sweetness and rate of melt. Cursory inspection shows Cote d’Or is more intense in brown color, cocoa aroma, snap, hardness, bitterness, creaminess and oily film formation. On the other hand, Koetjesreep had the highest gloss, caramel aroma, grittiness and residuals while lowest in brown color, snap, hardness, bitterness and oily film formation. The profile of Carrefour is mostly in between the empty spaces between the two other samples.

In summary, the QDA® supported the findings of Vitova et al. (2009) that milk chocolate with replaced vegetable fat was deficient in all sensory parameters. In this study, Koetjesreep which had a different type of fat compared to the other samples was found to be inferior in terms of all the textural attributes (hardness, snap, grittiness, creaminess and residuals).
4.3 Consumer Testing

4.3.1. Socio-demographic characteristics of respondents

From among the 131 respondents who participated in the consumer testing in the SensoLab, 126 satisfactorily completed the questionnaire. The other questionnaires which were deemed to be incomplete or with many missing data were not included. The sample comprised of 70 (55.56%) females and 57 (45.24%) males. The majority of respondents were between the age 18-25 (92.06%) followed by 3.17% between 26-30 years old. Similarly, majority (88.89%) are students while 7.93% are working. The rest are housewives. In terms of educational attainment, majority (89.68%) are in college, 6.35% finished secondary school and 3.17% are in graduate school. More than half of the respondents (57.94%) prefer milk chocolate over those who prefer dark chocolate (27.78%) and white chocolate (13.29%).

4.3.2. Overall acceptability

The affective ratings of the consumers (n=126) are presented as the overall acceptability ratings and the just about right (JAR) data. Table 5 shows the mean overall acceptability or liking scores of the chocolate samples. Significant differences were found in consumer’s overall liking for the samples (p≤0.05). Mean separation indicated by Tukey’s HSD multiple comparison tests showed that Cote d’Or was significantly higher (mean score= 6.92) in overall acceptability compared to the other two samples. This may be attributed to the complementarity of the levels of the sensory attributes of Cote d’Or as revealed in the QDA® of the trained panel. Focusing on texture, the significantly lower grittiness and residuals of Cote d’Or and higher intensity of snap compared especially to Koetjesreep may account for the higher acceptability score. Afoakwa (1999) mentioned that it is desirable in chocolate to be a firm solid product with a good snap and with a smooth mouth feel. However, since food according to Lawless and Heymann (2010) is a multi-modal experience, the sensations from one sensory modality may influence judgments and perceptions from another, and as such, the overall acceptability may also be influenced. Therefore, although the textural characteristics of the Cote d’Or may have greatly influenced its acceptability, the other distinguishable sensory characteristics such as color, cocoa aroma, caramel aroma and milky aroma may have also some effect.
Table 5. Mean* overall acceptability/liking scores of the chocolate samples.

<table>
<thead>
<tr>
<th>Brand</th>
<th>Overall acceptability</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean*</td>
<td>SD</td>
</tr>
<tr>
<td><strong>Cote d'Or</strong></td>
<td>6.92(^A)</td>
<td>1.78</td>
</tr>
<tr>
<td><strong>Carrefour</strong></td>
<td>6.19(^B)</td>
<td>2.04</td>
</tr>
<tr>
<td><strong>Koetjes Reep</strong></td>
<td>4.72(^C)</td>
<td>1.82</td>
</tr>
</tbody>
</table>

*Means with the same letter superscript in a column are not different at 5% level of significance based on Tukey HSD. n=126

Figure 5 shows the distribution of the scores given by the consumer panel. It can be observed that the distribution of scores for Cote d’Or is oriented toward the ‘positive’ portion of the 9-point hedonic scale peaking at 8 (like very much). The same trend is followed by Carrefour although with lower scores. It is interesting to note that Koetjesreep’s score is distributed both on the ‘positive’ and ‘negative’ sides of the scale which explains its significantly lower mean overall acceptability. It can be assumed that respondents are divided with regard to its acceptability.

![Figure 5. Overall acceptability of chocolate samples from a 9-point hedonic scale (n=126)](image)

Q: Overall, how much do you like this chocolate sample?

4.3.3. Just about right (JAR) data

Figure 6 shows the distribution of the Just about right (JAR) scores for texture (hardness) of the three chocolate samples. Koetjesreep is evidently negatively perceived by a majority of the respondents (62.68%) to have a too soft texture and its ‘just about right’ score is rather small (19.05%). Moreover, 15.87% of the respondents answered that its texture is “much too soft”. No
respondent answered that Koetjesreep is “much too hard”. In contrast, Cote d’Or obtained the highest JAR score among all the samples (67.46%) which is indicative of an optimum level of hardness followed by Carrefour (JAR= 58.73%). Still, 23.81% of respondents answered that Carrefour is “too soft” while there was only 2.38% of respondents who mentioned that Cote d’Or was “too soft”. On the other hand, there were 15.08% of respondents who answered that Carrefour was “too hard” and 28.57% for Cote d’Or.

The JAR scores form the consumer panel logically complements the results of both the instrumental and QDA® hardness evaluation. In both instrumental and sensory tests, Cote d’Or obtained the highest intensity of hardness which is significantly different from the other two samples. On the other hand, Koetjesreep had the lowest hardness intensity. The JAR scores provide additional insight that although Cote d’Or had the highest hardness intensity, majority of the consumers find this to be “just about right”. This can be related to what Tuorila (1996), as cited by Januszewska and Viane (2001), calls the “hedonic optimum” or the best liked concentration or level of a particular attribute which varies among foods and across cultures. Still, Afoakwa (2009) pointed out that flavour is the most important sensory attribute of chocolates but it is influenced by aroma, taste and texture during consumption and in a more or less conscious way, chocolate consumers’ judgment is based on interplay of these intrinsic quality attributes of products.

Figure 6. Distribution of the Just about right (JAR) scores for texture (hardness) of the chocolate samples

Basis: All respondents; n=126. Data points in the Figure are percent frequencies at Just about right intensity.
Q. What do you think of the texture of this chocolate?
4.4 EsSence Profile™ Methodology: Consumer emotion measurement

Table 6 shows the total frequency percentage of consumers who checked each emotion term listed for each of the three chocolate samples presented monadically and without the brand label. Fourteen out of 39 emotions from the EsSence Profile™ list discriminated the three brands based on Cochran’s Q test. Ten of them were positive (energetic, enthusiastic, glad, happy, merry, nostalgic, pleased, pleasant, satisfied and warm), two were negative (bored and disgusted) and two with no clear classification (daring and wild) (King and Meiselman, 2010). Pairwise comparison for each emotion makes it possible to explore the differences denoted by capital letter superscripts based on McNemar Test.

Generally, average frequency across all emotions ranged from 0 to 48 in which negative emotions obtained lower frequencies compared to positive emotions. This support the findings of other authors who observed that majority of emotional self-reports on food in published literature are positive since eating is basically a positive experience for healthy people and the point that actual food products are meant to please the consumers (Gibson 2006; Desmet & Schifferstein, 2008). It is also consistent with the study of Thomson et al. (2010) who also worked with unbranded dark chocolate where they found more positive than negative emotions. Moreover, it is widely known that chocolate has a hedonistic appeal to most people (Paoletti et al. 2012). Macht and Dettmer (2006) had similar findings that eating chocolate induces both positive and negative emotional changes in healthy, normal-weight women in their natural environment.
**Table 6. Comparison of emotions associated with chocolate samples (%); N=126**

<table>
<thead>
<tr>
<th>Emotion</th>
<th>Cote d’Or</th>
<th>Koetjesreep</th>
<th>Carrefour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active</td>
<td>19</td>
<td>12</td>
<td>19</td>
</tr>
<tr>
<td>Adventurous</td>
<td>1</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Affectionate</td>
<td>1</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>Aggressive</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Bored</td>
<td>3&lt;sup&gt;B&lt;/sup&gt;</td>
<td>17&lt;sup&gt;A&lt;/sup&gt;</td>
<td>1&lt;sup&gt;C&lt;/sup&gt;</td>
</tr>
<tr>
<td>Calm</td>
<td>37</td>
<td>42</td>
<td>38</td>
</tr>
<tr>
<td>Daring</td>
<td>6&lt;sup&gt;A&lt;/sup&gt;</td>
<td>1&lt;sup&gt;B&lt;/sup&gt;</td>
<td>3&lt;sup&gt;B&lt;/sup&gt;</td>
</tr>
<tr>
<td>Disgusted</td>
<td>3&lt;sup&gt;B&lt;/sup&gt;</td>
<td>13&lt;sup&gt;A&lt;/sup&gt;</td>
<td>1&lt;sup&gt;B&lt;/sup&gt;</td>
</tr>
<tr>
<td>Eager</td>
<td>1</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Energetic</td>
<td>25&lt;sup&gt;A&lt;/sup&gt;</td>
<td>7&lt;sup&gt;B&lt;/sup&gt;</td>
<td>14&lt;sup&gt;A&lt;/sup&gt;</td>
</tr>
<tr>
<td>Enthusiastic</td>
<td>31&lt;sup&gt;A&lt;/sup&gt;</td>
<td>16&lt;sup&gt;C&lt;/sup&gt;</td>
<td>25&lt;sup&gt;B&lt;/sup&gt;</td>
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</tr>
<tr>
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<td>38</td>
<td>30</td>
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<tr>
<td>Glad</td>
<td>42&lt;sup&gt;A&lt;/sup&gt;</td>
<td>25&lt;sup&gt;B&lt;/sup&gt;</td>
<td>35&lt;sup&gt;B&lt;/sup&gt;</td>
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<td>Good</td>
<td>48</td>
<td>48</td>
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<tr>
<td>Good-natured</td>
<td>17</td>
<td>15</td>
<td>2</td>
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<tr>
<td>Guilty</td>
<td>6</td>
<td>7</td>
<td>7</td>
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<tr>
<td>Happy</td>
<td>41&lt;sup&gt;A&lt;/sup&gt;</td>
<td>27&lt;sup&gt;B&lt;/sup&gt;</td>
<td>29&lt;sup&gt;B&lt;/sup&gt;</td>
</tr>
<tr>
<td>Interested</td>
<td>14</td>
<td>13</td>
<td>18</td>
</tr>
<tr>
<td>Joyful</td>
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<tr>
<td>Loving</td>
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<td>11</td>
<td>1</td>
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<tr>
<td>Merry</td>
<td>37&lt;sup&gt;A&lt;/sup&gt;</td>
<td>19&lt;sup&gt;B&lt;/sup&gt;</td>
<td>21&lt;sup&gt;AB&lt;/sup&gt;</td>
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<tr>
<td>Mild</td>
<td>9</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>Nostalgic</td>
<td>6&lt;sup&gt;B&lt;/sup&gt;</td>
<td>14&lt;sup&gt;A&lt;/sup&gt;</td>
<td>6&lt;sup&gt;B&lt;/sup&gt;</td>
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<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Pleasant</td>
<td>35&lt;sup&gt;A&lt;/sup&gt;</td>
<td>22&lt;sup&gt;B&lt;/sup&gt;</td>
<td>37&lt;sup&gt;AB&lt;/sup&gt;</td>
</tr>
<tr>
<td>Pleased</td>
<td>48&lt;sup&gt;A&lt;/sup&gt;</td>
<td>32&lt;sup&gt;B&lt;/sup&gt;</td>
<td>45&lt;sup&gt;A&lt;/sup&gt;</td>
</tr>
<tr>
<td>Polite</td>
<td>15</td>
<td>23</td>
<td>15</td>
</tr>
<tr>
<td>Quiet</td>
<td>21</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Satisfied</td>
<td>33&lt;sup&gt;A&lt;/sup&gt;</td>
<td>19&lt;sup&gt;B&lt;/sup&gt;</td>
<td>24&lt;sup&gt;AB&lt;/sup&gt;</td>
</tr>
<tr>
<td>Secure</td>
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<td>6</td>
<td>4</td>
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<tr>
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<td>7</td>
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<tr>
<td>Tame</td>
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<td>1</td>
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<td>Tender</td>
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<td>13</td>
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<tr>
<td>Understanding</td>
<td>9</td>
<td>14</td>
<td>11</td>
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<tr>
<td>Warm</td>
<td>38&lt;sup&gt;A&lt;/sup&gt;</td>
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<td>19&lt;sup&gt;B&lt;/sup&gt;</td>
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<td>Wild</td>
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<td>2&lt;sup&gt;A&lt;/sup&gt;</td>
<td>0&lt;sup&gt;B&lt;/sup&gt;</td>
</tr>
<tr>
<td>Worried</td>
<td>6</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

<sup>+</sup> Positive, <sup>-</sup> negative, <sup>u</sup> no clear classification based from King and Meiselman (2010)

<sup>ABC</sup> Means not sharing the same letter superscripts within a row are significantly different (P ≤ 0.05) based on McNemar Test
All samples were associated with positive emotions ‘calm’, ‘friendly’ and ‘good’ and have relatively high (30-48%) average frequency. They were not significantly different from each other (p<0.05) in terms of these emotions. Significantly higher average frequency (p<0.05) were obtained by Cote d’Or (42%) and Carrefour (35%) for the positive emotion ‘glad’ compared with Koetjesreep (25%). The same trend is observed for the positive emotion ‘pleased’.

Cote d’Or showed to be superior in terms of positive emotions ‘happy’, ‘warm’, ‘enthusiastic’, ‘energetic’ and ‘satisfied’, obtaining significantly higher (p<0.05) average frequencies (33-42%) than the other two chocolates which were 10 units average frequency lower. Carrefour however, did not differ significantly from Cote d’Or with the positive emotion ‘merry’ with an average frequency of 21%.

In terms of negative emotions, Koetjesreep was rated to be significantly higher (p<0.05) in terms of ‘bored’ (17%) and ‘disgusted’ (13%) compared with the other two chocolate samples. In another negative emotion ‘guilty’, all the brands obtained some but relatively low responses (6-8%). This can be explained by the perception of some people that chocolate is unhealthy (Szogyi, 1997).

It is particularly interesting to note that Koetjesreep obtained significantly higher (p<0.05) ‘nostalgic’ emotion average frequency (14%) compared with the other samples. Personal interviews with the respondents who checked that emotion during the consumer testing revealed that after tasting the products, they are reminded of their childhood and they somewhat recognize the taste from when they were children. Moreover, they mentioned that it is a traditional or old brand of chocolate that they were fond of eating during their childhood. The result of the acceptability test showed that the consumers are somewhat divided in terms of their liking of Koetjesreep. The ‘nostalgic’ emotion may help explain why some respondents gave a higher acceptability score for Koetjesreep. Since nostalgia is a part of people’s consumption experience and, therefore, a part of preference or choice (Goulding, 2001 as cited by Bambauer-Sachse and Gierl, 2009).
4.5 Relationship of overall acceptability and sensory characteristics (Hypothesis 2)

Partial Least Square Regression (PLR) was performed on the QDA® and overall acceptability data to determine the ‘drivers of liking’. It allows the identification of attributes/emotions that are positively or negatively correlated with overall acceptability (Meullenet, Xiong and Findlay, 2007). The landscape segment analysis (LSA) map (Figure 8) shows that positive ‘drivers of liking’ are color, cocoa aroma, snap, hardness and oily-film formation. If a product scores well along these attributes, overall liking will increase. Therefore, this explains the significantly higher overall acceptability of Cote d’Or compared to the other samples. Moreover, drivers of liking will change degree of liking as the physical stimulus magnitude changes which is the sensory-liking function which shows a peak on the function at a specific optimum sensory level (Moskowitz, 2002). On the other hand, the negative drivers of liking are caramel aroma, grittiness and residuals which are all present at intense level in Koetjesreep.
Figure 8. Landscape segment analysis (LSA) map of sensory attributes and overall acceptability based on Partial Least Square Regression

4.6 Correlation between emotions and overall acceptability

Correspondence analysis (CA) was performed on the average frequency of consumer responses for each emotion term with overall acceptability as supplementary variable as suggested by Ng, Chaya and Hort, 2013) for ‘check-all-that-apply’ data. As the computed p-value is lower than the significance level alpha=0.1, it was concluded that there is a link between the emotions and the products. This resulted in two dimensions where dimension 1 accounted for 85.5% of variance in the data and dimension 2 accounted for 14% of variance. The CA plot shows the product positioning in the emotional space.

The most liked product, Cote d’Or, is positioned with mostly positive emotions – ‘joyful’, ‘happy’, ‘merry’, and ‘adventurous’ but also the unclassified emotion ‘daring’. Meanwhile, Carrefour is strongly associated with positive emotions such as ‘pleasant’, ‘good-natured’, ‘active’, ‘steady’ and ‘whole’. Finally, most of the few negative emotions are related to Koetjesreep such as ‘bored’ and ‘disgusted’. However, it has also its share of some positive emotions such as ‘calm’, tender’ and ‘friendly’. Koetjesreep is the chocolate in which the emotion ‘nostalgic’ is mostly correlated.
Partial Least Square Regression (PLR) was also performed on the emotion and overall liking data to determine the ‘drivers of liking’. The landscape segment analysis (LSA) map (Figure 10) shows the emotions which are positive ‘drivers of liking’. These emotions are ‘eager’, ‘energetic’, ‘enthusiastic’, ‘free’, ‘glad’, ‘happy’, ‘joyful’, ‘pleased’, ‘satisfied’, ‘whole’ and the unclassified emotion ‘daring’ and ‘steady’ which were mostly associated with ‘Cote d’Or’. On the other hand, the emotions which are negative drivers of liking are mostly and expectedly the negatively classified emotions by King and Meiselman (2010) which are ‘bored’, ‘disgusted’ and to a certain extent, worried and guilty. However, it is also surprising to note that the positive emotion ‘calm’ emerged as a negative driver of liking. This can be explained by the multidimensional circumplex models of emotional response by Larsen and Deiner (1992) in which they classified emotions along $45^0$ angles within each quadrant as activated pleasant, activated unpleasant, unactivated pleasant and unactivated unpleasant. Thus, ‘calm’ which can be categorized as an unactivated pleasant emotion was associated negatively to overall liking. The same can also be said about ‘tender’, ‘nostalgic’ and the unclassified emotion ‘understanding’. It is also remarkable that the groupings of the emotions in the CA plot reflects the categorization of Larsen and Deiner (1992).
In summary, differences of the chocolate samples in terms of instrumental and sensory characteristics were established especially in terms of textural characteristics. Consumer testing revealed that Cote d’Or was the most acceptable sample, followed by Carrefour and Koetjesreep. The EsSence Profile™ methodology for emotion testing also revealed that each type of chocolate had a distinct emotional profile. Furthermore, investigating the relationship of sensory attributes and overall acceptability showed that textural characteristics such as harness, snap, oily-film formation were positive drivers of liking while grittiness and residuals influenced overall acceptability in a negative way. More insight was provided by the emotions where Cote d’Or was associated with the most number of positive emotions most of which were significantly different from the other samples. Koetjesreep on the other hand was associated with most of the negative emotions.

Figure 10. Landscape segment analysis (LSA) map of emotions and overall acceptability based on Partial Least Square Regression
CONCLUSIONS AND RECOMMENDATIONS

This study aimed to determine the influence of texture on Belgian consumer emotions and their affective or hedonic ratings. This was explored using three commercial brands of chocolates (Cote d’Or, Carrefour and Koetjesreep) by means of instrumental analyses colorimetry, texture analysis and differential scanning calorimetry (DSC), descriptive sensory analysis by QDA® with a trained panel (n=8), consumer acceptance testing and emotion testing by the EsSense Profile™ methodology using a consumer panel (n=126).

The instrumental analyses on color, texture and melting behavior revealed significant differences among the three commercial brands of chocolates that were used as samples in this study. Color analysis showed that in terms of lightness (L*), Carrefour was significantly lighter than Cote d’Or and Koetjesreep. All the samples obtained positive values in the other color aspects such as the +a* (red) + b* (yellow) values where Koetjesreep was significantly higher. Since color is a combination of these three aspects, although Carrefour was lighter, Koetjesreep was still perceived in the descriptive analysis to have the least intense brown color while Cote d’Or was the most intense. In terms of DSC, Koetjesreep was found to have a significantly higher melting point than the other two samples and the difference of shape of its melting line confirms the information on its label that it contains another type of fat which is hydrogenated vegetable oil. The presence of two peaks in Carrefour on the other hand may suggest partial fat substitution or the effect of milk fat while the single peak in Cote d’Or confirms that it contains pure cocoa butter.

The first hypothesis aimed to explore differences of samples based on instrumental texture and descriptive sensory analysis. Instrumental texture analysis on hardness by penetrometer showed that Cote d’Or was the significantly the hardest followed by Carrefour and the softest was Koetjesreep. On the other hand, the chocolate samples were well differentiated in terms of their sensory characteristics. Quantitative descriptive analysis proved to be an effective tool in generating attribute descriptors and majority (12 out of 15) were good discriminators of product difference of the chocolate samples based on appearance, aroma, taste and texture. In terms of textural characteristics, the trained panel judged that Cote d’Or had the highest intensity of hardness while Koetjesreep had the lowest which confirms the instrumental hardness test. Moreover, Koetjesreep scored the highest on grittiness and presence of residuals. Carrefour on the other hand had attribute intensities in between Cote d’Or and Koetjesreep. No significant difference was found on the rate of melting of the chocolate samples. Therefore, the first hypothesis is supported since differences of the chocolate samples in terms of instrumental texture and sensory characteristics were established.
The second hypothesis of the study was the overall acceptability of chocolate samples used in this study is influenced by differences in sensory characteristics. Consumer acceptance testing with 126 untrained respondents using a 9-point hedonic scale revealed that Cote d’Or was significantly the most liked sample (6.92) followed by Carrefour (6.19) and Koetjesreep (4.72). Furthermore, the ‘just about right’ (JAR) scores of the consumers showed that the texture (hardness) of Cote d’Or was in the optimal level which can further explain its higher overall acceptability. Carrefour obtained lower JAR score (58.7%) compared to Cote d’Or (67.5%) while Koetjesreep was deemed too soft by majority of the consumers (62.7%) and its JAR score is very low (19.1%). This proved to have a direct bearing on its low overall acceptability. Partial Least Square Regression (PSLR) between overall acceptability and the sensory attributes showed the relationship of the two and revealed that color, cocoa aroma, bitterness, hardness and snap were the ‘drivers of liking’. As such, this explained why Cote d’Or was the most acceptable since it was perceived to be the highest with respect to these attributes. Conversely, since Koetjesreep scored low on these sensory attributes and was found to have higher intensities of negative drivers of liking like caramel aroma and grittiness. In this regard, the second hypothesis is supported.

The third hypothesis examines the relation of chocolates with different sensory-textural characteristics and their emotion profiles. The EsSense Profile Methodology™ showed that samples were associated with positive emotions ‘calm’, ‘friendly’ and ‘good’ and have relatively high (30-48%) average frequency. Cote d’Or showed to be superior in terms of positive emotions ‘happy’, ‘warm’, ‘enthusiastic’, ‘energetic’ and ‘satisfied’, obtaining significantly higher average frequencies (33-42%). It can be attributed to its optimal hardness, relative smoothness and very low residuals. However, the other positive emotions may also be influenced by it a distinct cocoa aroma and bitterness. Carrefour, did not differ significantly from Cote d’Or with the positive emotion ‘merry’. Koetjesreep was associated with the negative emotions ‘bored’ and ‘disgusted’ which may be due to its soft texture, grittiness and high residuals. Interestingly, Koetjesreep was the only sample associated with the ‘nostalgic’ emotion. It was found out from the respondents that they were reminded of their childhood since it is a traditional or old brand of chocolate that they were fond of eating during their childhood. The ‘nostalgic’ emotion may help explain why some respondents gave a higher acceptability score for Koetjesreep and thus can be used for its marketing strategy.

The fourth and last hypothesis dealt with emotion profile of a chocolate and its relation to overall acceptability. Partial Least Square Regression performed on the emotion and overall liking data showed that the emotions ‘eager’, ‘energetic’, ‘enthusiastic’, ‘free’, ‘glad’, ‘happy’, ‘joyful’, ‘pleased’, ‘satisfied’, ‘whole’, ‘daring’ and ‘steady’ were positive drivers of liking. Clearly these emotions were mostly associated with Cote d’Or. On the other hand, the emotions which are
negative drivers of liking are ‘bored’, ‘disgusted’ and to a certain extent, ‘worried’ and ‘guilty’. However, it is also surprising to note that the positive emotion ‘calm’ emerged as a negative driver of liking which can be explained by the multidimensional circumplex models of emotional response in which ‘calm’ can be categorized as an inactivated pleasant emotion was associated negatively to overall liking. As such, the information on the emotions associated with the chocolate samples provided additional insights that complement and further explain the overall liking results.

As a summary, this study established sensory and instrumental differences on textural characteristics of the commercial chocolate samples. It can be concluded that differences on texture of the chocolate products influenced the affective ratings of consumers and the emotions that the chocolate evokes. However, since differences in other sensory characteristics like color, aroma and taste were also established, the overall acceptability and emotional profile of the chocolates cannot be solely attributed to the influence of texture since food perception is a multi-modal experience. This is one of the limitations of the study. Therefore, in order to more specifically define the influence of texture for future studies, it is recommended to investigate laboratory-produced chocolates with similar appearance, aroma and taste but with varied texture (by particle size distribution, ingredients, tempering). In addition, the data collection used for the emotions was the ‘check-all-that-apply’ method. For future research, the 5-point Likert-like scaling method can also be explored to allow for other means of statistical analysis. Moreover, it is also particularly interesting to look into the effect of consumption of chocolate on the affective ratings and emotional profile, as well as the physiological state of consumers since it was not tackled in this research. Nonetheless, this study is already one step in exploring how sensory characteristics, overall acceptability and the emotional responses are interrelated which, if harnessed effectively, can offer many interesting insights and be used for competitive marketing in the chocolate industry.
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Please write sample code: ____________

Name: ____________________________ Date: ____________________________

A. APPEARANCE
1) COLOR (BROWN)

| light brown | dark brown |

2) GLOSS/ SURFACE SHINE

| dull | glossy |

B. AROMA (Smell the chocolate sample)
3) COCOA AROMA

| none | intense |

4) CARAMEL AROMA

| none | intense |

5) VANILLA AROMA

| none | intense |

6) MILKY AROMA

| none | intense |

At this point: Bite through the chocolate sample using your incisors (front teeth) in order to have two equal pieces. (Evaluate the snap and hardness). Please set aside the other half of the sample for later questions.
C1. TEXTURE (First bite) and TASTE
5) CRISPNESS/SNAP (The noise and force with which the sample breaks or fractures)

| none | intense |
| Dark chocolate |

6) HARDNESS (force required to compress the food)

| very soft | very hard |
| Dark chocolate |

7) SWEETNESS

| none | intense |
| White chocolate |

8) BITTERNESS

| none | intense |
| Dark chocolate |

C2. TEXTURE (Masticatory phase)
At this point: Please place the other half of the sample on your mouth between your tongue and palate and manipulate/chew it completely. Evaluate the following:

9) GRAININESS/GRITTINESS (amount of solid particles)

| smooth | grainy |
| untempered chocolate |

10) CREAMINESS

| lacking | intense |
| white chocolate |

11) RATE OF MELT

| slow | fast |

12) OILY/ GREASY FILM (Amount of oil left on mouth surfaces)

| none | very much |

13) RESIDUAL (amount of solid particles left in mouth)

| none | very much |

Comments (if any): ___________________________________________________

THANK YOU VERY MUCH! 😊
CONSUMER TESTING OF CHOCOLATE Part 1

SAMPLE CODE NUMBER: _____________

Please taste the chocolate sample now.

Question: How much do you LIKE or DISLIKE the product? Please check the box.

<table>
<thead>
<tr>
<th>Dislike extremely</th>
<th>Dislike very much</th>
<th>Dislike moderately</th>
<th>Dislike slightly</th>
<th>Neutraal (Neither like nor dislike)</th>
<th>Like slightly</th>
<th>Like moderately</th>
<th>Like very much</th>
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</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
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<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Please select the words that describe how you FEEL RIGHT NOW. Check all that apply.

☐ Active (Actief) ☐ Glad (Blij) ☐ Pleased (Tevreden)
☐ Adventurous (Avontuurlijk) ☐ Good (Goed) ☐ Polite (Beleefd)
☐ Affectionate (Hartelijk) ☐ Good-natured (Goeddardig) ☐ Quiet (Stilte)
☐ Aggressive (Agressief) ☐ Guilty (Schuldig) ☐ Satisfied (Voldaan)
☐ Bored (Vervelen) ☐ Happy (Gelukkig) ☐ Secure (Veilig)
☐ Calm (Calmte) ☐ Interested (Belangstellend) ☐ Steady (Vast)
☐ Daring (Moedig) ☐ Joyful (Verblijdend) ☐ Tame (Tam)
☐ Disgusted (Vol afkeer) ☐ Loving (Liefhebbend) ☐ Tender (Zacht)
☐ Eager (Vurig/ verlangend) ☐ Merry (Vrolijk) ☐ Understanding (Begrip)
☐ Energetic (Energiel) ☐ Mild (Licht) ☐ Warm (Warmte/ Hartelijk)
☐ Enthusiastic (Enthousiast) ☐ Nostalgic (Nostalgisch) ☐ Whole (Totaal)
☐ Free (Vrij) ☐ Peaceful (Vredig) ☐ Wild (Wilde)
☐ Friendly (Vriendelijk) ☐ Pleasant (Aangenaam) ☐ Worried (Bezorgd)

What do you think about the TEXTURE of this Chocolate? Please check

<table>
<thead>
<tr>
<th>Much too soft</th>
<th>Just Right</th>
<th>Much too hard</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
CONSUMER TESTING OF CHOCOLATE Part 2

SOCIO-DEMOGRAPHIC INFORMATION

1. Please indicate your age group
   - younger than 18
   - 18 – 25
   - 26 – 30
   - 31 – 40
   - 41 – 50
   - 51 – 60
   - 61 – 70
   - older than 70

2. Please indicate your sex:
   - Male
   - Female

3. In what City or Town in Belgium do you live? ______________________________

4. How far did you go in school?
   - elementary school
   - high school
   - college/ university
   - graduate school

5. Please check the one which best applies to you
   - student
   - home maker
   - employed (part time)
   - employed (full time)
   - self-employed
   - not employed

6. Do you watch your weight?
   - yes
   - no

7. What is your height in meters? _____ meters

8. What is your weight in kilograms? _____ kg

Thank you very much for your participation!
### APPENDIX 3
Definition of attributes used by the trained panel to evaluate the chocolate samples

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td></td>
</tr>
<tr>
<td>1. Brown Color</td>
<td>The intensity of brown color from light to dark brown</td>
</tr>
<tr>
<td>2. Gloss/ Surface shine</td>
<td>Luminescence of colour, with descriptions ranging from dull to shiny.</td>
</tr>
<tr>
<td>Aromatics</td>
<td></td>
</tr>
<tr>
<td>3. Cocoa aroma</td>
<td>The aromatic associated with cocoa powder</td>
</tr>
<tr>
<td>4. Caramel aroma</td>
<td>The aromatic associated with caramelising sugar without burning it</td>
</tr>
<tr>
<td>5. Vanilla aroma</td>
<td>The aromatic associated with vanilla or vanillin</td>
</tr>
<tr>
<td>6. Milky aroma</td>
<td>The aromatic associated with fresh or pasteurized milk</td>
</tr>
<tr>
<td>Taste</td>
<td></td>
</tr>
<tr>
<td>7. Sweet Taste</td>
<td>The taste on the tongue associated with sucrose (sugar)</td>
</tr>
<tr>
<td>8. Bitterness Taste</td>
<td>The taste on the tongue associated with caffeine</td>
</tr>
<tr>
<td>Texture</td>
<td></td>
</tr>
<tr>
<td>9. Snap</td>
<td>The noise and force with which the sample breaks or fractures</td>
</tr>
<tr>
<td>10. Hardness</td>
<td>The force required to compress the chocolate</td>
</tr>
<tr>
<td>11. Graininess/ Grittiness</td>
<td>The amount of solid particles during mastication</td>
</tr>
<tr>
<td>12. Creaminess</td>
<td>The mouth-feel related to the smoothness of the chocolate as related to fat</td>
</tr>
<tr>
<td>13. Rate of melt</td>
<td>The amount of time it takes to melt the chocolate in the mouth</td>
</tr>
<tr>
<td>14. Oily/ greasy film</td>
<td>The amount of oil left on mouth surfaces</td>
</tr>
<tr>
<td>15. Residual</td>
<td>The amount of solid particles left in mouth after swallowing</td>
</tr>
</tbody>
</table>
APPENDIX 4
Photographs during the Sensory Evaluation and Consumer Testing

Appendix 4.1 The three brands of chocolates used in the study
(Left: Koetjesreep; Center: Carrefour; Right: Cote d’Or)

Appendix 4.2 Some of the trained panel members during the QDA familiarization on the qualitative phase

Appendix 4.3 The coded chocolate samples presented for QDA (Left) and consumer testing (Right) according to sensory evaluation standards
Appendix 4.4 The author gives the samples to the respondents during the consumer testing.

Appendix 4.5 The Belgian respondents during the consumer testing as they evaluate the coded and randomized chocolate samples one at a time.