# THE SENSORY PROFILE OF MILK CHOCOLATES: USING THE RATE-ALL-THAT-APPLY (RATA) METHODOLOGY

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**ABSTRACT**

The current challenging economic environment and move towards healthier choices are causing behavioural changes among consumers as they are shifting towards more economical purchases and perceived healthier chocolate products. To match consumers' recent expectations and stay competitive in the local confectionary market, the determination of sensory attributes of representative products by a trained panel provides key information for product development and marketing. Therefore, the aim of this paper is to determine the sensory profile of selected milk chocolates applying the RATA (rate-all-that-apply) methodology. A sweet aroma and flavour, cocoa powder and milky flavour as well as a creamy mouthfeel were moderately to very experienced for all the chocolate samples. The extracted factors for the milk chocolates included mouthfeel (texture), bitterness and sweetness. Chocolates 1 (artificially sweetened), 3 (imported indulgence) and 6 (everyday luxury) were identified as representative sensory profiles for milk chocolate as they varied between low, medium and high-intensity ratings for various attributes and could serve as a prototype for future product development. An understanding of the intensity of sensory attributes within this food category could assist the local confectionary market towards extending product offerings by including more economical and healthier products.

**KEYWORDS**

rate-all-that-apply, trained panel, sensory profile, sensory attributes

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## INTRODUCTION

Chocolate is a well-known product and one of the most consumed snacks worldwide. South Africa's chocolate confectionary market is well -established and valued at R5.03-billion (Foodstuffs 2024). As reported by the Observatory of Economic Complexity (OEC), from July 2024, the export of South Africa's chocolate has increased by 13.9% from R142-million to R162-million (to countries such as Namibia, Mauritius and Mozambique), while imports also increased by 14.6% from R172-million to R197-million (from countries such as Belgium, Italy and Poland) (OEC 2024).

Milk chocolate is defined as chocolate that consists of milk and milk products (such as milk powder), cocoa, and sugar. Milk powder is one of the main ingredients of milk chocolate (Glicerina, Balestra, Rosa & Romani 2015). In milk chocolate, cocoa butter stabilises the cocoa particles and solid sugar (Lapčíková *et al*. 2022). Consequently, milk powder and cocoa butter can influence physical, rheological and sensory attributes of chocolates (Glicerina, Balestra, Rosa & Romani 2016).

The current challenging economic environment is causing behavioural changes among consumers as they are shifting towards more economical purchases of chocolate products. Producers need to stay competitive in the local market whilst still delivering against consumers' expectations of this category. Growth opportunities for the local confectionary industry lie in the manufacturing of cost-effective products tailored towards price-sensitive consumers. In addition, there is an increasing demand for healthier alternatives within the confectionery sector, which presents a niche market for innovation and diversification. Product innovation is critical for a company's survival in a competitive global market to achieve profitable growth and increase competitiveness (Biazzo, Panizzolo & de Crescenzo 2016). The fact, however, is that the vast majority of newly launched food products fail to achieve sales targets (Stewart-Knox & Mitchell 2003). Furthermore, one of the main challenges for the confectionary industry is the lack of understanding of the sensory attributes of a food category to steer product formulation design towards making specific changes to product formulations to match consumer demands (Agudelo, Varela & Fiszman 2015). Since chocolate has a complex and unique flavour, taste and mouthfeel profile (Brown, Warren, Ingraham, Ziegler & Hopfer 2023), it is imperative for the future success of the South African confectionery industry when developing new products, to choose a product formulation whose sensory attributes deliver against consumer expectations and results in acceptance (van Kleef, van Trijp & Luning 2006). However, variations in terminology and methodology employed in sensory evaluation, combined with the fact that each process through which chocolate is produced, may result in differentiated and distinct sensory attributes, have resulted in inconsistencies and discrepancies in obtained results (Putri, De Steur, Juvinal, Gellynck & Schouteten 2024).

Sensory research has broad application as it allows the making of informed business decisions (Stone & Sidel 2004), guides product development to match a consumer's ideal or to get closer to a benchmark (Brody & Lord 2007) and measures the impact of ingredient or process changes (Sharif, Masoos & Muhammmad 2017). It is also implemented for quality control purposes to track product change over time and to correlate findings with other instrumental measurements (Varela & Ares 2012).

The use of sensory evaluation methods is gaining traction within the chocolate industries and is projected to grow in importance (Putri *et al*. 2024) as it can identify sensory attributes essential for consumer acceptance

(Reinbach, Giacalone, Ribeiro, Bredie & Frøst 2014). Sensory evaluation can be categorised into objective and subjective testing. In subjective testing, the consumer's perception of a product's sensory attributes is determined (Kemp, Hollowood & Hort 2011). The sensory and hedonic experiences and perceptions of products are regarded as crucial factors for consumers' food choices (Tuorila 2007), and accordingly, describing the sensory attributes of products is a common procedure in the food and beverage industry.

In objective testing, a product's sensory attributes are evaluated by a trained panel. In many instances, trained panels are involved in the early stages of a project to gain sensory knowledge (Delarue 2015) which involves discrimination (to determine if there are any sensory differences between samples) and description (identifying the nature of sensory differences and/or the intensity of these differences) of the sensory attributes of products (Meilgaard, Carr & Civille 2006). Descriptive sensory methods have remained one of the most comprehensively used tools in sensory science (Varela & Ares 2012), as they pinpoint differences among products (Yang & Lee 2019). Many food manufacturers still use trained panels to accurately profile products using descriptive sensory methods (Stone, Bleibaum and Thomas 2020).

Sensory attributes are often measured using the RATA (rate-all-that-apply) methodology – it is a rapid and accurate method that allows panellists to select attributes that are relevant for the food sample test and then rate the attribute's intensity or applicability (Ares *et al*. 2014). The RATA measurement tool, a variation of check-all-that-apply (CATA), was designed to measure the presence and intensity of sensory attributes of food products. When compared to the CATA method, RATA is useful for the in-depth characterisation of products and focuses more on the intensity of terms (Meiselman 2015), particularly when the intensity differs, as RATA questions ensure the obtainment of reliable intensity scores for the sensory attributes (Ares *et al*. 2011). As panellists are asked to select and rate all the attributes applicable from a list to the product being evaluated, RATA is therefore considered a more analytical approach for panellists to measure the sensory attributes of products (Schouteten *et al*. 2015). Recently, Kitani, Putri and Fukusaki (2022) used RATA to evaluate chocolate bar samples and it showed promise as a methodology for the sensory evaluation of chocolate even as part of a quality control process.

In many sensory analysis studies, one of the main reasons to request subjects to assess products has been to conceive the sensory attributes that discriminate amongst these products (Lê, Husson & Lê 2016). When the objective is to assess or measure sensory attributes, it is important that samples presented to panellists stretch the spectrum of the sensory space that is being assessed with no redundancy (Chaya *et al*. 2015).

To deliver against consumer's current expectations and stay competitive in the evolving local confectionary market, the determination of sensory attributes by a trained panel provides key information for product development and marketing, as it provides context of the variation in sensory attributes which consumers are currently exposed to. Therefore, the aim of this paper was to determine the sensory profile of milk chocolates sold at local retailers using the RATA (rate-all-that-apply) methodology.

## MATERIALS AND METHODS

### Ethical approval

This study received ethical approval (NWU-00029-17-A1). The execution of the study was

within the parameters presented to the ethics committee. All the panellists were required to give informed consent and participation in this study was completely voluntary. Panellists received a list of ingredients of all the chocolates samples to ensure they were not allergic to any of the ingredients. Panellists were not misled, nor was any information regarding the study withheld from them.

**Chocolate samples**

Milk chocolate (tablet form) sold at local retailers was chosen for this study to generate the sensory profile of milk chocolate products sold in South Africa's retail space. The trained panel evaluated 12 milk chocolate samples and then reduced it to six milk chocolate products of which the results are presented in this paper. Chocolate 1 was an artificially sweetened milk chocolate aimed at diabetics. Chocolates 2 and 3 were premium imported chocolates positioned towards indulgence. Chocolates 4, 5 and 6 were mainstream chocolates marketed as an everyday luxury.

**Selection of the trained panel**

This panel consisted of six people who had all been trained to determine the intensity of the sensory attributes of milk chocolate. The panellists were all employed by an international flavour and fragrance manufacturer and had considerable exposure across different food products, including chocolate, and more specifically local food products. The trained sensory panel were informed that the ultimate objective was to determine the sensory profile of milk chocolates applying the RATA methodology. Once the panellists were informed about the study they were given the option to agree or decline to participate in the study. The panellists were screened prior to participation for recognition of the basic tastes and a descriptive test.

The panel process usually involves vocabulary development, including eliminating synonymous or redundant attributes, in order to reduce the number of attributes. In some instances, vocabulary is not developed, but the panel will use an existing list of characteristics or lexicons (Rogers 2017). In this study, a list of descriptors was developed by an extensive review of literature which reported on the sensory attributes of chocolate. References are often included to reduce panellist variability of the interpretation of the characteristics (Kilcast & Subramaniam 2011), which was implemented in this study. Trained panellists first identified and then quantified the food product's sensory characteristics using suitable intensity scales to perform statistical analysis (Marques, Correia, Dinis & Vilela 2022).

**Sensory attributes**

In order to determine the sensory profile of milk chocolate, the appearance, aroma, flavour, mouthfeel and aftertaste attributes were included in the questionnaire. A sensory list of 49 sensory attributes was compiled from previous research studies. Varela and Ares (2012) confirmed that sensory attributes could be chosen for studies by reviewing results from previous sensory and consumer research studies, and therefore, this approach was applied to this study. The list of 49 sensory attributes was also compared to a list of sensory attributes created by Schouteten *et al*. (2015), in which consumer-defined lexicons (attributes) were included to ensure alignment between the sensory attributes and consumer preferences.

Not all attributes in this study were expected to contribute equally to the discrimination between the set of milk chocolate products that were studied as they could not all be equally relevant and would thus not offer the opportunity to understand and quantify key differences, however, through the study key

**TABLE 1: ATTRIBUTES, DEFINITIONS AND REFERENCES USED BY A TRAINED SENSORY PANEL TO EVALUATE MILK CHOCOLATES**

| Attribute | Definition | Reference |
|---|---|---|
| ***Appearance*** | | |
| **Gloss** | The amount of light reflected from the surface | Not applicable |
| ***Aroma*** | | |
| **Sweet** | Aroma characteristic of sweet products | Confectionary and sweets |
| ***Flavour*** | | |
| **Bitter** | Taste of aloe, caffeine and hop bitters | Coffee, aloe juice, tonic water |
| **Burnt** | Flavour of overheated or scorched starch or sugar | Burnt sugar, burnt toast |
| **Cocoa powder** | Brown, sweet often bitter flavour | Cocoa beans, cocoa powder |
| **Coffee** | Flavour of coffee and coffee beans | Coffee power, coffee beans |
| **Milky** | Flavour associated with milk and milk products | Milk and cultured dairy products |
| **Sweet** | Taste delivered by sugar | Sucrose, fructose, artificial sweeteners |
| **Vanilla** | Flavour of vanilla | Vanilla pods, vanilla essence |
| ***Mouthfeel*** | | |
| **Adherence** | The amount that sticks to tooth surfaces | Not applicable |
| **Creaminess** | Resembles the consistency of cream | Not applicable |
| **Melting** | The length of time for it to melt in the mouth | Not applicable |
| **Mouth-coating** | The amount of film or coating left on mouth surfaces | Not applicable |
| ***Aftertaste*** | | |
| **Bitter aftertaste** | Aftertaste delivered by substances such as quinine, caffeine and hop bitters | Coffee, aloe juice, tonic water |

attributes were identified and the list of attributes was reduced. At first, each of the sensory attributes was reviewed by the trained panel across the various chocolate samples, and the mean score for each attribute in each chocolate was compared to see if similar scores were achieved across the chocolate samples. If a low variance between the lowest and highest scores was noted (less than 1 regarded as a meaningful interval of the 5-point scale), the sensory attribute was eliminated by the trained panel from the list. In order to further reduce the number of attributes, synonymous or redundant attributes were subsequently eliminated.

Through the above process, the list of 49 sensory attributes was reduced to 14 attributes (Table 1) as the trained panel identified the sensory attributes which best described and discriminated between the milk chocolate products included in this study. Furthermore, a definition was provided for each sensory attribute, and where possible, a reference product was also included (Table 1).

**Sample evaluation by trained panel**

The trained panel sensorially evaluated 12 chocolate samples using 49 sensory attributes in individual booths at a sensory evaluation facility in Johannesburg, South Africa. The evaluation took place over six working days spanning two weeks for two hours each day as the panel evaluated one sample per hour. Sessions were conducted early morning and late afternoon, at least two hours after the panellists consumed breakfast and lunch, as testing shortly after meals and coffee breaks may introduce bias (Meilgaard *et al*. 2006). Therefore, the sessions were spaced six hours apart to reduce fatigue during evaluation. Bottled mineral water and water biscuits (Carr's® brand) served as palette cleansers during the sensory evaluation task.

**RATA Measurement Tool**

The RATA method, as described by Stone *et al*. (2020) was employed to measure the intensity of the 14 sensory attributes through the use of a five-point Likert scale (0=Not at

**TABLE 2: SENSORY ATTRIBUTES OF SIX MILK CHOCOLATES**

| Attribute | Choc. 1 | Choc. 2 | Choc. 3 | Choc. 4 | Choc. 5 | Choc. 6 | Mean |
|---|---|---|---|---|---|---|---|
| ***Appearance*** | | | | | | | |
| **Gloss** | 1.0* | 1.0* | 2.0 | 1.8 | **2.5**** | 1.5** | 1.63 |
| ***Aroma*** | | | | | | | |
| **Sweet** | 2.3* | **2.5** | **3.0** | **2.8**** | **3.0** | **3.3**** | **2.79** |
| ***Flavour*** | | | | | | | |
| **Bitter** | 0.8*** | 0.5 | 0.0* | 0.3** | 0.3** | 0.3** | 0.33 |
| **Burnt** | 0.5 | 0.5 | 0.0* | 0.5 | 0.5 | 0.5 | 0.42 |
| **Cocoa powder** | **2.5** | 2.3** | 1.5* | 2.3** | 2.3** | **2.8**** | 2.25 |
| **Coffee** | 0.8 | 0.5** | 0.3* | 0.5** | 0.8 | 1.0*** | 0.63 |
| **Milky** | 1.5 | **2.8** | **3.0**** | 1.5 | **2.8** | 1.3* | 2.13 |
| **Sweet** | 2.3* | 2.3* | **3.0**** | **2.5**** | **3.0**** | **3.0**** | **2.67** |
| **Vanilla** | 1.5** | 2.0*** | 1.8 | 1.3 | 1.5** | 0.8* | 1.46 |
| ***Mouthfeel*** | | | | | | | |
| **Adherence** | 0.5* | 1.0** | 1.5 | 1.5 | 1.8*** | 1.0** | 1.21 |
| **Creaminess** | 2.3** | **2.5** | **3.0**** | 1.8 | 2.3** | 1.3* | 2.17 |
| **Melting** | 1.5** | 1.8 | 2.0*** | 1.8 | 1.8 | 1.0* | 1.63 |
| **Mouth-coating** | 1.0 | 1.5** | 1.7 | 1.5** | 1.8*** | 0.8* | 1.36 |
| ***Aftertaste*** | | | | | | | |
| **Bitter aftertaste** | 0.5 | 0.8*** | 0.0* | 0.3** | 0.0* | 0.3** | 0.29 |

Notes: *Likert scale (Level of intensity experienced): 0=Not at all, 1=Slightly, 2=Moderately, 3=Very, 4=Extremely;* Interpretation of means: <1.0=Not experienced at all, ≥1.0-<2.0=Slightly experienced, ≥2.0-<3.0=Moderately experienced ≥3.0-<4.0=Very experienced and 4.0=Extremely experienced. Values in bold = highest values ≥2.5.

all, 1=Slightly, 2=Moderately, 3=Very, 4=Extremely). Giacalone, Bredie and Frøst (2013) found that with a trained panel, the RATA scale resulted in good reproducibility at panel level, with a high level of agreement between product lists acquired from individual replicates, and it also indicated good reliability for individual sensory attributes.

### Statistical analysis

Data was analysed with IBM SPSS Statistics (Version 25, Release 23.0). Means were reported for the sensory attributes measured on a Likert scale (RATA method). Exploratory factor analysis (EFA) was performed to reduce the individual factors into fewer dimensions. An Oblimin rotation with Kaiser normalisation, was performed. Kaiser Meyer-Olkin measure of sampling adequacy and Bartlett's test of sphericity were reported. Kaiser's criterion was used to determine the number of factors to extract (Field 2009). For internal consistency, Cronbach's alpha was reported (Shrestha 2021). In addition, mean factor scores were calculated for each factor.

## RESULTS

### Descriptive analysis of milk chocolates

Table 2 indicates the mean values of the sensory attributes of each milk chocolate. Mean values equal to or above 2.5 are highlighted and indicate the intensity of the attributes experienced moderately to very: chocolate 1 (artificially sweetened) presents a cocoa powder flavour (2.5); chocolate 2 (imported indulgence) shows a sweet aroma (2.5), milky flavour (2.8) and creaminess mouthfeel (2.5); chocolate 3 (imported indulgence) indicates a sweet aroma (3.0), milky- and sweet flavour (3.0), and creaminess mouthfeel (3.0); chocolate 4 (everyday luxury) presents a sweet aroma (2.8) and sweet flavour (2.5); chocolate 5 (everyday luxury) reveals a gloss appearance (2.5), sweet aroma (3.0), milky- (2.8) and sweet flavour (3.0); and chocolate 6 (everyday luxury) shows a sweet aroma (3.3), cocoa powder- (2.8) and sweet flavour (3.0) (Table 2).

**TABLE 3: EXTRACTED FACTORS FOR THE MOUTHFEEL, BITTERNESS AND SWEETNESS ATTRIBUTES OF MILK CHOCOLATE**

| | Mouthfeel | Bitterness | Sweetness |
|---|---|---|---|
| **Creaminess mouthfeel** | 0.904 | | |
| **Melting mouthfeel** | 0.808 | | |
| **Milky flavour** | 0.787 | | |
| **Vanilla flavour** | 0.734 | | |
| **Mouth-coating mouthfeel** | 0.713 | | |
| **Coffee flavour** | | 0.925 | |
| **Cocoa powder flavour** | | 0.899 | |
| **Burnt flavour** | | 0.877 | |
| **Bitter aftertaste** | | 0.848 | |
| **Bitter flavour** | | 0.815 | |
| **Gloss appearance** | | | 0.863 |
| **Sweet flavour** | | | 0.818 |
| **Sweet aroma** | | | 0.812 |
| **Adherence mouthfeel** | | | 0.803 |
| **Inter-item correlation** | 0.660 | 0.734 | 0.612 |
| **Cronbach's Alpha** | 0.893 | 0.921 | 0.862 |
| **Mean factor score** | 1.600 | 1.010 | 2.140 |

Notes: *Likert scale: 0=Not at all, 1=Slightly, 2=Moderately, 3=Very, 4=Extremely*; Mean factor loading score and interpretation of means: <1.0=Not present at all, ≥1-<2.0=Slightly present, ≥2.0-<3.0=Moderately present, ≥3.0-<4.0=very present and 4.0=Extremely present; Cronbach's Alpha: α≥0.5=accepted with caution, α≥0.7=Acceptable, α≥0.8=Good; Shaded loadings indicate items that loaded meaningful on one factor.

**Extracted factors of sensory attributes**

Table 3 presents the EFA of the sensory attributes of the milk chocolate samples. The three extracted factors are identified as mouthfeel (texture), bitterness and sweetness. For mouthfeel (factor 1), a creaminess (0.904) and melting (0.808) mouthfeel indicated high loadings. For bitterness (factor 2), all factors indicated high loadings above 0.8 and a coffee flavour (0.925) showed the highest loading. For sweetness (factor 3), all factors revealed high loadings above 0.8 and a gloss appearance (0.863) indicated the highest loading. The mean values of the three factors for the milk chocolates indicated that sweetness (2.140) was moderately present followed by mouthfeel (1.600) and bitterness (1.010) which were slightly present. The inter-item correlation values for mouthfeel (0.660), bitterness (0.734) and sweetness (0.612) are within the acceptable range for internal consistency. The Cronbach alpha values for mouthfeel (0.893), bitterness (0.921) and sweetness (0.862) were satisfactory for internal reliability (Table 3).

**Ranking of the chocolates based on factor ranking**

Table 4 presents the rankings of the milk chocolates' mouthfeel, bitterness and sweetness based on the means of the extracted factors. The mean ratings for each of the three factors extracted were calculated for each chocolate in order to identify the chocolates' intensity experienced and rank them either low, medium or high (Table 3). The mean factor scores were calculated for each factor. These factor scores were summarised by reporting means. For mouthfeel (factor 1), chocolates 2 (2.12) and 3 (2.3) indicated the highest intensity. For the bitterness (factor 2), chocolates 1 (1.02) and 6 (0.98) showed the highest intensity. Considering the high intensity of sweetness (factor 3) experienced by the panellists, it would seem that chocolates 3 (2.38) and 5 (2.58) delivered the highest intensity (Table 4).

**TABLE 4: RANKING OF MILK CHOCOLATES' MOUTHFEEL, BITTERNESS AND SWEETNESS BASED ON THE MEANS OF THE EXTRACTED FACTORS**

| Chocolate | Mouthfeel | | Bitterness | | Sweetness | |
|---|---|---|---|---|---|---|
| | Mean | Ranking | Mean | Ranking | Mean | Ranking |
| **Chocolate 1** | 1.58 | 4 | 1.02 | 1 | 1.53 | 6 |
| **Chocolate 2** | 2.12 | 2 | 0.92 | 3 | 1.70 | 5 |
| **Chocolate 3** | 2.30 | 1 | 0.36 | 6 | 2.38 | 2 |
| **Chocolate 4** | 1.58 | 4 | 0.78 | 4 | 2.15 | 4 |
| **Chocolate 5** | 2.04 | 3 | 0.78 | 4 | 2.58 | 1 |
| **Chocolate 6** | 1.04 | 6 | 0.98 | 2 | 2.20 | 3 |

Notes: 1-2 = high ranking and -intensity; 3-4 = medium ranking and – intensity; 5-6 = low ranking and -intensity.

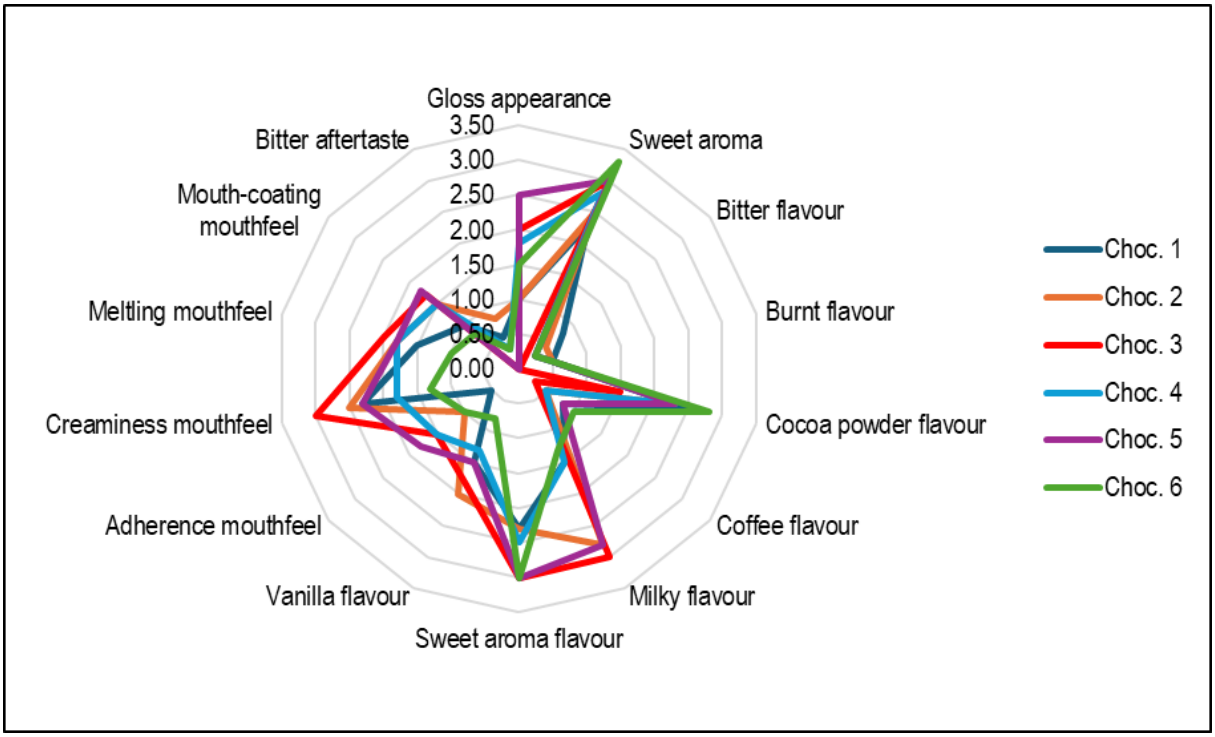


**FIGURE 1: SENSORY PROFILE OF MILK CHOCOLATES**

**Sensory profile of milk chocolates**

Figure 1 presents a sensory profile of the six milk chocolates evaluated by the trained panel. Chocolate 1 (artificially sweetened) delivered four attributes with the lowest scores, two characteristics with the highest scores, and moderate values for three attributes. Chocolate 2 (imported indulgence) delivered only one single lowest score and two highest values, with three attributes rated as moderate. Chocolate 3 (imported indulgence) provided the lowest scores for five attributes and the highest scores for four attributes. Chocolate 4 (everyday luxury) did not deliver the highest or lowest ratings for any of the sensory attributes. For eight of the sensory attributes, it was rated as average. Chocolate 5 (everyday luxury) had the lowest scores on one attribute, the highest on four attributes and moderate ratings for three attributes. Chocolate 6 (everyday luxury) was moderate for four attributes, highest for two attributes and lowest for three attributes.

Figure 2 shows the sensory profile of the three

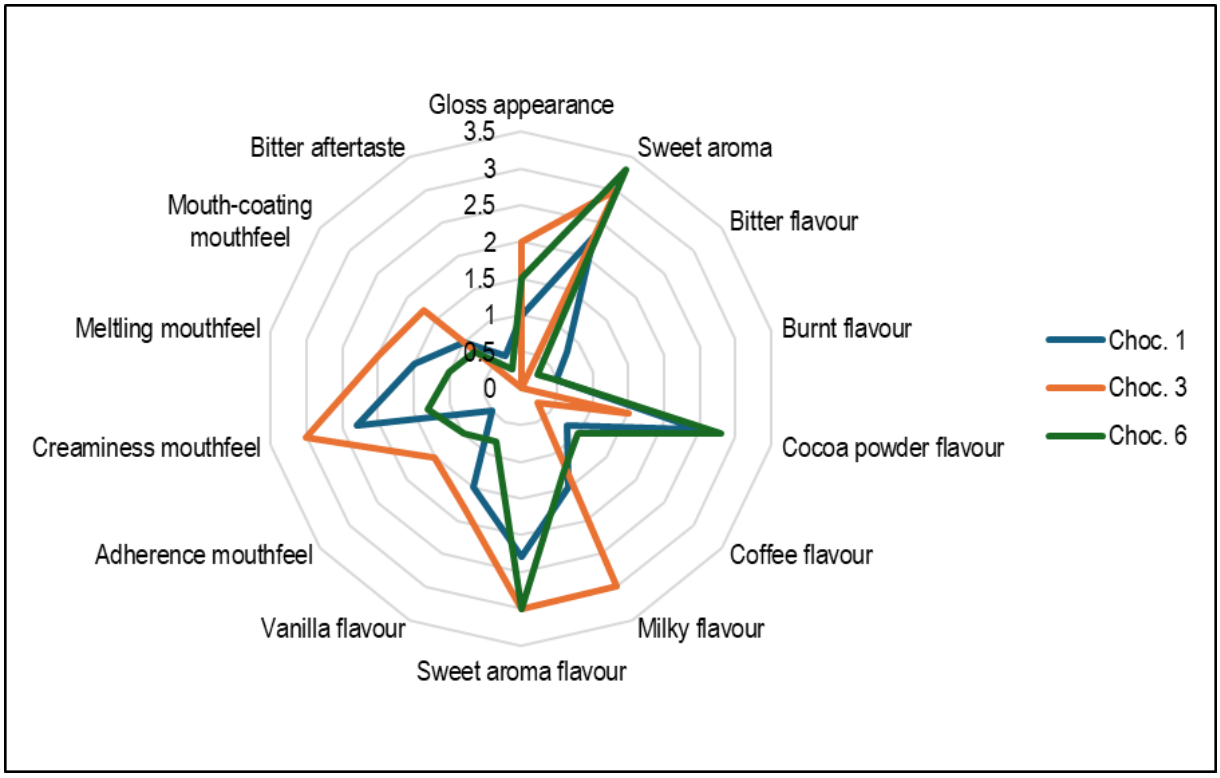


**FIGURE 1: SENSORY PROFILE OF MILK CHOCOLATE VARIED BETWEEN LOW, MEDIUM AND HIGH INTENSITY RATINGS**

milk chocolates chosen by the trained panel that varied between low, medium and high-intensity ratings. The trained panel identified chocolates 1 (artificially sweetened), 3 (imported indulgence) and 6 (everyday luxury) to be used as the standard sensory profiles for milk chocolate as they varied between low, medium and high-intensity ratings. Higher ratings for the sensory attributes, sweet aroma, cocoa powder flavour, sweet aroma flavour, and creaminess mouthfeel are evident.

## DISCUSSION

### Descriptive analysis of milk chocolates

When considering the intensity of the sensory attributes (Table 2) experienced for all milk chocolate samples, a sweet- aroma and flavour, cocoa powder flavour, creaminess mouthfeel and milky flavour are moderately to very experienced by the trained panel. A study by Guinard and Mazzucchelli (1999) determined the effects of sugar and fat on the sensory properties of milk chocolate and found that while samples low in sugar and fat were associated with cocoa, fatty, mouthcoating and viscous notes, samples higher in sugar had higher sweetness, vanilla and milk notes. Da Silva *et al*. (2013) found that milk chocolate samples indicated a higher intensity for the attributes; sweetness, spreadable, and adhesiveness. A study by De Pelsmaeker, De Clercq Gellynck and Schouteten (2019) found the flavours perceived in milk chocolate with the highest intensity were caramel, milk/cream and cocoa. Mielmann and Brunner (2022) measured the sensory properties of chocolate-based biscuits and found a chocolate and sweet taste was the most intense taste experienced.

### Extracted factors of sensory attributes

As also confirmed from the mean values in Table 3, the mean factor score for sweetness

is the highest which indicates the intensity of this factor experienced by the trained panel ranged between moderately to very. De Pelsmaeker *et al*. (2019) confirmed that sweetness is more linked to milk chocolate than to white chocolate and Januszeska *et al*. (2020) indicated that the attributes sweet taste and cocoa/chocolate flavour were dominant in the flavour profiling of milk chocolate samples.

Mouthfeel (texture) of chocolate plays a fundamental role in describing its sensory quality and flavour attributes due to the milk solid's particle size being equally distributed. In order to produce an optimum particle size distribution, fine grinding should be applied which influences the flavour, texture and flow attributes of the end product (Toker, Palabiyik, Pirouzian, Aktar & Konar 2020). Furthermore, tempering influences chocolate's texture as different textures can influence stimuli release, oral behaviour and their residence in the mouth. Adequately, tempered chocolate has a uniform texture and uniform structure that protects and preserves the aroma compounds in the suspension. Chocolate texture is also affected by other factors including fat content, particle size distribution, emulsifiers, and moisture content (Ma, Ziegler & Hayes 2024).

Usually, people dislike bitterness and are even rejected in most foods. The presence of specific compounds such as methylxanthines (e.g. caffeine and theobromine), flavonoids (e.g. flavan-3-ols epicatechin, catechin), oligomers, and a variety of compounds in the 2,5-diketopiperazine (DKP) class are responsible for the bitter taste in chocolates (McClure, Hopfer & Grün 2022). As confirmed by Febrianto, Wang and Zhu (2022), it is known that cocoa flavonoids cause a bitter taste, notably in chocolate types containing high cocoa. Several of these compounds are even affected by growing conditions, cacao varietal, ripeness at the time of harvest, and post-harvest processes (e.g. fermentation and roasting). McClure *et al*. (2022) found that the geographical location, even within a single country, could influence the theobromine to caffeine ratio and methylxanthine concentration of cacao. Furthermore, during roasting, the concentrations of flavonoid epicatechin as well as diketopiperazines (DKPs) from peptides are created which are responsible for the bitter and astringent sensory attributes (McClure *et al*. 2022). According to Afoakwa, Paterson, Fowler and Ryan (2008), the African types of cacao have excellent character as these varieties contribute to caramelised, astringency, acidity, burnt and bitter flavours.

Sweet taste is a driver of liking for many foods, such as chocolates, as it contributes to about 50% of the total mass of chocolate (Ma *et al*. 2024). A study by de Pelsmaeker (2019) confirmed that a sweet taste is more linked to milk chocolate than to white chocolate. In addition, the presence of amino acids in chocolates plays a fundamental role in the flavours of chocolate. For example, the reaction between glucose and valine forms sensory notes of "penetrating chocolate", glutamine and threonine with glucose form a "chocolate" aroma, and glucose and leucine produce an aroma described as "sweet chocolate" (Muñoz, Cortina, Vaillant & Parra 2019). Pedersen, Bertelsen Byrne and Kidmose (2023) found that reducing the fat concentration considerably lowered the sweetness intensity of the chocolate and reducing the sucrose concentration, did influence the creaminess flavour as a reduction in sucrose, decreased the perception of this flavour. When the quantity of either fat and sucrose or both, or together, is changed, it is imperative to consider both the direct i.e. altering the sucrose changes the level of sweetness, and the indirect effects. Therefore, when the aim is to make sugar and/or fat-reduced chocolates acceptable to consumers, it is important to inspect how the entire product will be affected by the decreased levels of fat and sugar.

**Ranking of the chocolates based on factor ranking**

From the results (Table 4), it is evident that chocolate 3 (imported indulgence) was found by the trained panel to be the most sensorily varied due to the low intensity of bitterness and high intensity of both mouthfeel and sweetness. Da Silva *et al*. (2013) confirmed that milk chocolates showed low intensity for the sensory attributes, firmness and bitterness. Chocolate 4 (everyday luxury) ranked medium across all three factors for mouthfeel, bitterness and sweetness. When looking at local chocolate brands, chocolate 5 (everyday luxury) indicated high intensity for sweetness and medium intensity for mouthfeel and bitterness.

**Sensory profile of milk chocolates**

The combination of these three chocolates offers the acceptable inclusion of low, moderate or high mean scores for many of the sensory attributes and a good sensory spread to use in product formulations (Figures 1 & 2). It is evident that the three chocolates stretch the spectrum of the sensory space with no redundancy (Chaya *et al*. 2015) and although a global list of sensory attributes is important for standardisation and effective communication (Lemarcq, Van de Walle, Monterde, Sioriki & Dewettinck 2022), recognising local variations is equally vital for capturing the rich diversity within the local confectionary industry (Putri *et al*. 2024). The narrowed-down list of descriptors was more specific to the local products.

The three milk chocolates' sensory attributes and the relationship between these can be used to expand the South African confectionary market as they are a good representation of the sensory variance in the local market and thus the common profiles to which consumers are exposed. Consumers are now gravitating towards nutrient-dense, naturally occurring resources due to the quickly growing trend of healthy eating and conscientious consumerism (Sarıtaş *et al*. 2024), however developing healthier milk chocolates means removing or reducing sugar that will naturally, affect the sweet taste, but will also affect other tastes such as sourness and bitterness due to taste-to-taste interactions (Pedersen *et al*. 2023), including the appearance, aroma, texture and shelf life of the product. If manufacturers are aiming to introduce healthier products, they could potentially enhance it with a variety of useful or functional ingredients since it is not only seen as a sweet delight but also as a potential product that promotes a healthier way of living, viewed as a food with added ingredients which enhance healthiness (Hu *et al*. 2020).

**Value of study to the confectionary market**

Considering the growth in this sector of the confectionary market along with the current challenging economic environment, findings from this study can support product developers to deliver chocolates from different price categories which deliver against consumers' expectations while still being profitable and competitive in the market (Biazzo, Panizzolo & de Crescenzo 2016). An increased understanding of sensory attributes will support growth opportunities for the local confectionary industry towards manufacturing cost-effective products tailored towards price-sensitive consumers (Agudelo, Varela & Fiszman 2015).

## CONCLUSIONS

A sweet aroma and flavour, cocoa powder and milky flavour as well as creaminess mouthfeel, were moderately to very experienced for all the chocolate samples. The extracted factors for the milk chocolates included mouthfeel (texture), bitterness and

sweetness. Chocolates 1 (artificially sweetened), 3 (imported indulgence) and 6 (everyday luxury) were identified as standard sensory profiles for milk chocolate as they varied between low, medium and high-intensity ratings and can serve as a prototype for future product development. Identifying and quantifying sensory attributes and creating sensory frameworks will assist the local confectionary market expand to more economical and healthier products. The results of this study can be beneficial to the stakeholders in the confectionary industry as they can use and apply the sensory attributes of milk chocolate in their product formulations to meet consumers' needs which can possibly lead to a more sustainable success rate of their products.

## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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