Master’s thesis
Christina Magelund

Sensory Evaluation and Consumer Acceptance of New Premium Dark Chocolates

Date of submission
September 1st 2013

Academic advisors
Main supervisor: Michael Bom Frøst
Co-supervisors: Garry Lee & Belinda Nielsen
Abstract

The global market for premium chocolates has increased significantly within the recent years as a result of a growing consumer demand for high quality products. This has also increased the search for heirloom fine flavour cocoa genetics which has enhanced the awareness of the cocoa potential in the Pacific region. Cocoa flavours are influenced by numerous factors including cocoa genetics, origin, and farming practices. Furthermore, the sensory quality of chocolate is affected by manufacturing processes including roasting, conching and tempering. The sensory characteristics of a food product is important for consumer acceptance and food choice behaviour, although food consumption is also influenced by other factors such as brand, price, availability, context and demographics. Previous exposures and perceptions of collative properties are also influencing hedonic liking which must be considered in product development and marketing strategies.

The aim of this study was to investigate sensory characteristics and consumer acceptance of six plain dark chocolates including samples with cocoa from Papua New Guinea (PNG) and Solomon Islands. Four premium (single-origin) and two mass-produced chocolates were evaluated by 88 consumers in Perth, 38 men and 50 women. A descriptive analysis of each sample was obtained by use of a modified version of the CATA-method. The consumers evaluated the samples on 24 flavour and mouthfeel attributes and simultaneously rated liking and perceptions of collative properties (novel, ordinary, high quality). Consumer background information was also collected in the study.

Results showed that five of the six samples were significantly different in sensory characteristics. The largest difference was seen between the mass-produced and the premium chocolates. Bitter, drying, mouldy, earthy, spicy, smoky, tobacco, acidic, and roasted were correlated to the premium chocolates whereas smooth, sweet, caramel, nutty, and buttery were characterizing the mass-produced samples. Significant differences were also found for liking with average scores ranging from 5.03-6.74 on the 9-point scale. The mass-produced chocolates got the highest average scores, and among the premium chocolates the PNG sample got the highest average score of 5.33 whereas the Solomon sample got the lowest score of 5.03. The difference in liking among the premium chocolates however was not significant. The properties ‘high quality’ and ‘novel’ were predictive for liking showing positive and negative correlations, respectively. Multivariate analysis revealed a large spread in liking and indicated various consumer segments related to liking of the different samples. Overall, the mass-produced samples were generally preferred by young consumers (18-25 years) with low incomes who most often consumed milk chocolate. Preference for the premium chocolates was dominated by older consumers with higher incomes. These consumers most often consumed dark chocolate and had a high interest in high quality food products. The majority of the consumers rated taste as most important for chocolate purchase.
Preface

This master’s thesis is the final work of the Master of Science degree in Gastronomy and Health from University of Copenhagen, Denmark. The thesis is based on the author’s own experimental work and data collection which have been carried out in collaboration with the University of Western Australia (UWA) and Bahen & Co. Chocolate who has produced samples for this study. The study is a component of a larger research project on heirloom cocoa varieties which is currently being conducted at UWA as part of an AusAID project in the Pacific region. The project includes research within the fields of analytical chemistry and sensory science. The present study encompasses only the sensory part of the research project and has been conducted at UWA in Perth in the period from March to June 2013. The study has been approved by the human research ethics committee at UWA (approval number RA/4/1/6086).

Acknowledgements

I wish to express my great appreciation to my external supervisor, Professor Garry Lee from UWA. Thank you for giving me the opportunity to work with you and this project. I am deeply grateful for your constant support and assistance with the research for this thesis. I would also like to offer my special thanks to my main supervisor, Associate Professor Michael Bom Frost, from the University of Copenhagen. I sincerely appreciate your time and professional guidance on this project.

The contributions by Bahen & Co. Chocolate are also deeply appreciated. Thank you for producing and delivering the chocolate samples for this study and for enabling me to visit your operation and providing me with valuable information for this report.

Furthermore, I am very grateful for the assistance and advice given by:

- Davide Giacalone – for the statistical help with the multivariate data analysis
- Bodil Allesen-Holm – for the technical assistance with PanelCheck and Unscrambler
- Belinda Nielsen – for the methodological guidance on sensory evaluation techniques
- Joanna McNabb & Kenny Ong – for the practical help with the data collection
- Pia Ingholt Hedelund – for reading the thesis and giving constructive feedback
- Mette Duerlund Hansen – for help and constructive feedback on the data analysis

I also wish to thank my family and friends, in particular Lars Skotte Jensen, for your love and moral support throughout this process.
# Table of Contents

**Abbreviations**

**Definitions of Cocoa and Chocolate Terms**

1.0 Introduction ........................................................................................................................................................................... 9

1.1 Background .............................................................................................................................................................................. 9

1.2 Bahen & Co. Chocolate ......................................................................................................................................................... 10

1.3 Purpose .................................................................................................................................................................................... 11

1.4 Objectives ................................................................................................................................................................................... 11

1.4.1 Research Questions .......................................................................................................................................................... 11

1.4.2 Delimitations ....................................................................................................................................................................... 12

1.5 Review of Literature and Research .................................................................................................................................... 13

1.6 Structure of the Report ............................................................................................................................................................ 14

2.0 The Cocoa Market ....................................................................................................................................................................... 15

2.1 Trends in Chocolate Consumption ..................................................................................................................................... 15

2.2 Global Cocoa Production ........................................................................................................................................................ 16

3.0 Theory on Cocoa and Chocolate ............................................................................................................................................. 17

3.1 Cocoa Bean Composition .......................................................................................................................................................... 17

3.1.1 Organic acids ...................................................................................................................................................................... 17

3.1.2 Polyphenols and Alkaloids ................................................................................................................................................. 18

3.2 Genetics and Origin ................................................................................................................................................................. 19

3.2.1 Cocoa Types ........................................................................................................................................................................ 19

3.2.2 Fine Flavour Cocoa ............................................................................................................................................................ 20

3.2.3 Geographical Origin .......................................................................................................................................................... 21

3.3 Post-Harvest Flavour Formation .......................................................................................................................................... 22

3.3.1 Farming practices ................................................................................................................................................................. 23

3.3.2 Chocolate Manufacturing Process .................................................................................................................................. 25
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACIAR</td>
<td>Australian Centre for International Agricultural Research</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
</tr>
<tr>
<td>A-PLSR</td>
<td>ANOVA Partial Least Square Regression</td>
</tr>
<tr>
<td>AusAID</td>
<td>Australian Agency for International Development</td>
</tr>
<tr>
<td>CATA</td>
<td>Check All That Apply</td>
</tr>
<tr>
<td>D-PLSR</td>
<td>Discriminant Partial Least Square Regression</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization</td>
</tr>
<tr>
<td>FCIA</td>
<td>Fine Chocolate Industry Association</td>
</tr>
<tr>
<td>ICCO</td>
<td>International Cocoa Organization</td>
</tr>
<tr>
<td>L-PLSR</td>
<td>L-shaped Partial Least Square Regression</td>
</tr>
<tr>
<td>PCA</td>
<td>Principal Component Analysis</td>
</tr>
<tr>
<td>PLSR</td>
<td>Partial Least Square Regression</td>
</tr>
<tr>
<td>PNG</td>
<td>Papua New Guinea</td>
</tr>
<tr>
<td>WA</td>
<td>Western Australia</td>
</tr>
<tr>
<td>WCF</td>
<td>World Cocoa Foundation</td>
</tr>
<tr>
<td>UWA</td>
<td>University of Western Australia</td>
</tr>
</tbody>
</table>
Definitions of Cocoa and Chocolate Terms

Cocoa solids and butter
Cocoa consists of both cocoa solids and cocoa butter. Cocoa solids are the components of the cocoa nibs which do not contain cocoa butter and are thus the low-fat part of the beans. Contrarily, cocoa butter is the fatty component and constitutes 48-57% of the dry weight of cocoa beans (Fowler, 2009; Afoakwa, 2010).

Heirloom Cocoa
Heirloom refers to something ‘antique’ or ‘original’. Heirloom cocoa genetics possess a combination of historic, cultural, genetic, geographical, and most importantly flavour value. Genetics are not a condition for heirloom classification, but comes second to flavour evaluation. Heirloom cocoa must present unique flavours worthy of preservation, protection and propagation (FCIA, 2013a).

Dark Chocolate
It has not been possible to find a clear definition of dark chocolate, and standards for chocolate products seem to vary between countries. In the Danish Consolidation Act of cocoa and chocolate products for instance it is claimed that dark chocolate must have a dry matter of cocoa of not less than 43% of which the content of cocoa butter should be minimum 26% (Fødevareministeriet, 2003). According to experts, the optimal cocoa content of dark chocolate is 60-70% (Tænk, 2010).

Premium Chocolate
The word premium comes from the Latin word praenium which means ‘reward’, ‘prize’, ‘exceptional quality’ or ‘greater value’. Premium chocolate is not just classified by a higher price it must also create a greater value for the consumer than other chocolates. This value is often driven by sensory quality, packaging, image and perception, and communication. Premium chocolates are typically single-origin, fair-trade, organic and/or high cocoa content chocolates produced with high quality cocoa (Linemayr, 2011; Pay, 2009).

Single-origin Chocolate
Chocolate produced with cocoa beans sourced from one single country or region. Typically dark chocolate bars made from scratch by small bean-to-bar manufacturers, often from directly sourced cocoa beans and accompanied by deep relationships with the farmers and the growing communities (Kitchen, 2012).
1.0 Introduction

1.1 Background
The global demand for premium chocolate products such as single-origin, fair-trade, organic and high cocoa content chocolates has increased rapidly within the recent years, and due to a generally growing consumer demand for high quality food products it is expected to continue. This has also increased the demand for heirloom ‘fine flavour’ cocoa which is used for the production of premium chocolates. Heirloom cocoa genetics are known for their distinctive and complex flavours obtained through the beans’ genetics, terroir, and postharvest processes. Today however, this type of cocoa exists in scarcity because in response to the demand from the corporate producers of industrial chocolate, growers continue to replace these cocoa trees with high-yield, disease-resistant and less flavourful hybrids and clones (FCIA, 2013a). This has increased the awareness of the Pacific Islands, which due to its isolation and small production base has largely escaped the attention of the industrial chocolate sector. Due to already existing production systems and unspoilt environments the Pacific region has a number of advantages to produce fine flavour cocoa. Production of this cocoa quality has the potential to double export prices and thereby to improve the livelihoods of the people in this region who have limited income opportunities. Nevertheless, 90% of Pacific cocoa is currently sold as bulk cocoa at base world price (Marfu, 2012; University of Queensland, 2012; PARDI, 2011). An ACIAR study from 2006 concluded that smallholders in this region could substantially improve the quality of the cocoa through optimized farming practices (ACIAR, 2013). As part of Australia’s contributions to fight poverty in the Pacific and to utilize the region’s cocoa potential a number of projects funded by AusAID and various NGOs have recently been established in the Pacific region with the overall aim of increasing cocoa production and improving quality in order to gain access into higher value markets (PARDI, 2012; AusAID, 2012).

For the premium chocolate industry however, the challenge is not only to source cocoa of a consistent high quality but also to produce chocolates which have a sufficiently broad appeal to the palates of consumers. Although food choice is affected by various factors such as demographics, availability, price and brand, hedonic liking is important for consumption behaviour. It is therefore essential that the sensory characteristics of a product are appealing to consumers in order for the product to have success on the market. Consumers however have different preferences and so it is also important to understand the variables explaining for liking among different consumer segments. For instance, previous research has shown that mere exposure and perceptions of collative properties including novelty are influencing individual preferences. For this reason, it is relevant not only to analyze the cocoa by analytical chemistry but also to test consumer perceptions and acceptability of the final product by use of sensory evaluation.
1.2 Bahen & Co. Chocolate
Bahen & Co. Chocolate is a small Australian bean-to-bar operation located in Margaret River which is the premier wine and gourmet region of WA. The company, which was founded five years ago by Josh Bahen, produces premium dark chocolates by using vintage machines and only two ingredients, cocoa and organic cane sugar. By producing chocolate in the old-fashioned way it is possible for Bahen & Co. to preserve the natural aromas and flavours that represent the growers and the unique characteristics of the plantations. The slow pace and desire for simplicity have so far resulted in a range of four unique premium dark chocolates; House Blend, Almond and Sea salt, and two single-origin bars, Madagascar and Brazil.

Bahen & Co.’s goal is to produce fine flavoured chocolate equal in quality to the world’s best and to be the leading producer in the Southern hemisphere by using some of the finest and rarest cocoa genetics in the world. The search for heirloom cocoa genetics and plantations is therefore an underlying major focus of Bahen & Co.’s activities. This search has now expanded to the Pacific region, including PNG and the Solomon Islands, where Josh Bahen is working in collaboration with AusAID to uncover heirloom genetics and to establish direct relationships with the farmers (Welker, 2012; Bahen & Co, 2013a). This work has lead to the production of the two new premium single-origin chocolates investigated in the present study.
1.3 Purpose
The purpose of this study is to obtain sensory data which combined with chemical analyses can be used to explore the flavour potential of cocoa beans sourced from plantations in the South Pacific region for the premium chocolate market.

1.4 Objectives
The objective of the study is to investigate the sensory characteristics and consumer acceptance of six dark chocolate samples including two single-origin chocolates produced with cocoa from PNG and the Solomon Islands, respectively. Furthermore, the objective is to investigate how hedonic liking and perceptions of collative properties vary between premium and mass-produced dark chocolates. From a theoretical point of view, it is also considered relevant to include descriptions of the various factors influencing the sensory properties of chocolate and hedonic liking.

Sensory research methods are used for data collection. Relevant sensory descriptors of dark chocolate are obtained from a group of chocolate specialists by use of a rapid profiling method. The descriptors are used as attributes in a descriptive test conducted with consumers in Perth. Moreover, hedonic responses and perceptions of collative properties are obtained for each of the samples from the same group of consumers.

The data is treated by univariate and multivariate statistics to investigate sample differences, and to study links between sensory characteristics, liking, and perceptions of collative properties. Various consumer background variables are included in the analysis to uncover potential consumer segments and underlying patterns of liking.

1.4.1 Research Questions
Which sensory differences exist among four single-origin dark chocolates made with cocoa beans sourced from various regions, and how are these chocolates different from two mass-produced dark chocolates in regards to sensory characteristics?

How do sensory characteristics of dark chocolate correlate to hedonic liking among consumers in Australia, and how do perceptions of the collative properties ‘novel’, ‘ordinary’, and ‘high quality’ correlate to the different samples and liking of dark chocolate?
1.4.2 Delimitations

- The samples used in this study are all plain dark chocolate bars with a cocoa content of 70%.

- Sensory characteristics are in this study limited to flavour and mouthfeel characteristics.

- The term ‘mass-produced’ is used for the chocolate samples from Green & Black’s and Cadbury whereas the samples from Bahen & Co. are referred to as ‘premium’ chocolates.

- The genetics of the cocoa beans used for the samples investigated in this study have not been assessed by analytical methods.

- The processes of fermentation and drying will be described from a general theoretical perspective and variations may therefore exist among the samples.

- Description of the chocolate production process is based on the methods used by Bahen & Co. and does therefore not apply to the mass-produced chocolates.
1.5 Review of Literature and Research

When scientific research is conducted it is relevant to look at existing literature and previous research to validate the relevance of the study and for comparison of results. This study is considered to be somewhat exploratory and a literature review has therefore been carried out with the aim of finding existing research on cocoa and dark chocolate which could support some of the findings of this study.

A comprehensive literature search revealed that extensive research has been conducted on aromas and flavours in cocoa and chocolate. In several studies it has been demonstrated that cocoa genetics, origin and post-harvest processes are influencing the presence and formation of various aroma compounds in cocoa. Information on this subject has thus been obtained from various studies and theoretical literature (Afoakwa, 2010; Camu et al., 2008; Fowler, 2009; Ziegleder, 2009). However, very little research is available on the flavour characteristics of cocoa from the geographical regions included in this study, especially the Pacific region.

Furthermore, most of the previous research on cocoa has been conducted by analytical chemistry and has thus not dealt with sensory data. Nevertheless, it has been demonstrated that sensory profiles of chocolate can be obtained from human subjects including consumers and that trained panellists are able to consistently differentiate between various chocolate flavours (Jinap, Dimick & Hollender, 1995; Sukha & Butler, 2006; Thamke, Dürrschmid & Rohma, 2009). In regards to consumers however, taste descriptors such as bitter, sweet and acidic have shown to be more useful for sample differentiation than flavour descriptors (Thamke, Dürrschmid & Rohma, 2009).

In regards to consumer liking and perceptions of dark chocolate it has been shown that acceptance of dark chocolates depends not only on the expectations generated by the information, brand and type of product, but mostly on the sensory characteristics of the chocolate (Torres-Moreno et al., 2012). However, liking is not consistent and differs widely among individuals which emphasize the relevance of conducting consumer studies. Theoretical literature and studies on food choice and preferences are extensive, and several researchers have proposed various hypotheses on the factors influencing liking including context, previous product experiences and perceptions of collative properties (Berlyne, 1970; Pliner, 1982; Zajonc, 1968; Meiselman, 2006).
1.6 Structure of the Report

2. Facts
The first part of the report presents facts about the present cocoa market, the global production and distribution of cocoa and current trends in chocolate consumption.

3. Theory
The first theoretical section describes the determining and influential factors on cocoa and chocolate flavour development and includes descriptions of genetic variations, geographical origins, and post-harvest processes from bean to bar. The next section describes some of the various factors influencing food choice and consumption of dark chocolate and presents psychological hypotheses on hedonic liking from a theoretical perspective.

5. Sensory Study
This section contains a detailed description of the methods, samples, assessors, test location, and experimental procedures used in the study. The section comprises of two parts; the first part relates to the initial specialist workshop and the rapid profiling, and the second part describes the consumer study which comprises of both descriptive and affective tests. A description of the methods used for the univariate and multivariate data analyses are also included in this section.

6. Results
This section first presents the sensory vocabulary obtained from the specialist workshop. Next, results from the consumer study are presented. This part comprises of an analysis of the data obtained from the descriptive and the affective tests. A combined analysis of all the data including consumer background variables is presented as the last part of this section.

7. Discussion
The results and choice of methods are discussed in comparison with previous research and the theories presented in the report. The discussion includes considerations in regards to the CATA-method, attributes, consumer responses, the choice of consumers, product exposure, and the context in which the samples were tested.

8. Conclusion
The overall conclusions of the findings from the study are presented. Furthermore, perspectives on the relevance of the results and further investigation of Pacific cocoa are described.
2.0 The Cocoa Market
According to FAO the worldwide imports of cocoa has increased continuously in the last two decades with an average annual growth rate of nearly 14 percent from 1997 to 2007 (Pay, 2009). Cocoa serves as an important crop around the world and 40-50 million people depend on cocoa for their livelihood. Cocoa is also a key import crop for several cocoa processing and consuming countries. Europe is by far the most dominating region of cocoa grindings and consumption followed by the United States. In 2011, the trading volume of cocoa exceeded production by 750,000 tonnes and global sales of chocolate confectionery crossed 100 billion USD for the first time. The demand for chocolate is expected to continue increasing and likely outpacing supply. Chocolate companies such as Cadbury are therefore looking around the world for new cocoa sources, including the Pacific region. This increases the need to support and improve cocoa farm sustainability worldwide (WCF, 2012; Pay, 2009; Solomon Times, 2013).

2.1 Trends in Chocolate Consumption
Along with the increasing demand for cocoa, the global market for premium chocolates has also grown significantly within the recent years, and the growth is expected to continue. Although premium chocolates currently count for less than 10% of the global chocolate market this category has expanded by 65% since 2002. The growth is especially seen in Western Europe and Northern America but also in Australia and in particular WA where the economy is currently booming and the living standards are generally high. This ‘new’ trend is an effect of an increased consumer demand for high quality products as well as a growing interest from chocolate manufacturers in this segment. The growing interest for high quality products can be explained by an increased concern among consumers about the health and safety of their food. The demand for high cocoa content products is related to an increased awareness of the health and nutritional benefits of cocoa. Additive-free chocolate for instance is predicted to become the norm in the nearest future. Organic and fair-trade chocolate has also become more popular which is related to a greater interest for the environmental and social implications of its production. Along with the increased awareness about health and sustainability consumers are now more willing to pay premium prices for high quality products. Moreover, premium chocolate is no longer confined to the higher income groups and has thus become an affordable luxury to a much larger group of consumers. The increased market potential for premium chocolate products has resulted in the existence of several new high-end chocolate businesses such as Bahen & Co. Chocolate (ICCO, 2010; Pay, 2009; Morris, 2012; King, 2012; Sivasailam, 2010).
2.2 Global Cocoa Production

Cocoa originates from South and Central America where it has been cultivated since before AD 600 by the Mayan and Aztec people who used the cocoa beans as currency for trading. Due to climatic reasons the cocoa tree, *Theobroma cacao*, is only able to grow in certain suitable environments in a belt between 10°N and 10°S of the Equator. The optimal conditions are in areas with temperatures within 18–32°C and an annual rainfall between 1500 and 2000 mm well distributed throughout the year. A hot and humid atmosphere is essential and in the areas of optimal growth humidity can be up to 100% (ICCO, 2013a). The cocoa tree grows naturally in the lower storey of the evergreen rain forest in the Amazon basin but cultivation of cocoa has now spread to various regions across the Equator (Afoakwa, 2010).

Today, West Africa, South East Asia and South America are the three main areas of cocoa production with West Africa counting for more than 70% of the world’s production (ICCO, 2013b). Within the three regions there are seven countries which count for 90% of the cocoa production these being Côte d’Ivoire, Ghana, Nigeria, and Cameroon in Africa, Indonesia in South East Asia, and Ecuador and Brazil in South America (Fowler, 2009). Table 1 below contains the latest figures from the Quarterly Bulletin of Cocoa Statistics presented by the International Cocoa Organization. The table provides an overview of how the global cocoa production is presently distributed.

<table>
<thead>
<tr>
<th>Region</th>
<th>2010/11</th>
<th>Estimates 2011/12</th>
<th>Forecasts 2012/13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>2224</td>
<td>2918</td>
<td>2920</td>
</tr>
<tr>
<td>Cameroon</td>
<td>225</td>
<td>297</td>
<td>295</td>
</tr>
<tr>
<td>Côte d’Ivoire</td>
<td>1411</td>
<td>1486</td>
<td>1475</td>
</tr>
<tr>
<td>Ghana</td>
<td>1026</td>
<td>879</td>
<td>820</td>
</tr>
<tr>
<td>Nigeria</td>
<td>240</td>
<td>296</td>
<td>220</td>
</tr>
<tr>
<td>Others</td>
<td>220</td>
<td>112</td>
<td>88</td>
</tr>
<tr>
<td>America</td>
<td>25</td>
<td>13.0%</td>
<td>6.5%</td>
</tr>
<tr>
<td>Brazil</td>
<td>200</td>
<td>220</td>
<td>195</td>
</tr>
<tr>
<td>Ecuador</td>
<td>161</td>
<td>190</td>
<td>185</td>
</tr>
<tr>
<td>Others</td>
<td>201</td>
<td>229</td>
<td>226</td>
</tr>
<tr>
<td>Asia &amp; Oceania</td>
<td>255</td>
<td>521</td>
<td>534</td>
</tr>
<tr>
<td>Indonesia</td>
<td>440</td>
<td>450</td>
<td>450</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>48</td>
<td>39</td>
<td>45</td>
</tr>
<tr>
<td>Others</td>
<td>39</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>World total</td>
<td>4311</td>
<td>100.0%</td>
<td>3967</td>
</tr>
</tbody>
</table>

PNG is the biggest cocoa producer in the Pacific followed by the Solomon Islands. The Pacific region however is only contributing with a small percentage of the world’s cocoa trade but as seen in Table 1 the production in Asia & Oceania is increasing (Sustainable Cocoa Initiative, 2013). This pattern is also seen for the South American region. Contrarily the cocoa production in West Africa seems to be decreasing.
3.0 Theory on Cocoa and Chocolate

3.1 Cocoa Bean Composition
Cocoa beans are the seeds found in the fruit pods of the cocoa tree. Each fruit pod contains 30–40 beans embedded in a mucilaginous pulp. The cocoa bean consists of two cotyledons (nibs) and a small embryo plant which are all enclosed in a shell. The shell represents only 10–16% of the bean weight whereas the nibs take up 78–82%. The remaining is moisture.

The nibs contain different macronutrients as well as numerous other compounds in varying amounts. There are two types of essential storage cells in the nib which contribute to the characteristic colour, flavour and aroma of chocolate. These are the polyphenolic cells and the lipid–protein cells. The chemical composition of cocoa beans however is very complex and varies among different bean types and origin of growth but the average composition of the main compounds is listed in Table 2 below (Afoakwa, 2010; Bertazzo et al., 2013).

Table 2: Average composition of whole ripe cocoa beans (Fowler, 2009; Ziegleder, 2009; Afoakwa, 2010)

<table>
<thead>
<tr>
<th>Compound</th>
<th>Content % dry weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat (cocoa butter)</td>
<td>48-57</td>
</tr>
<tr>
<td>Starch</td>
<td>5-9</td>
</tr>
<tr>
<td>Fibre (cellulose)</td>
<td>12</td>
</tr>
<tr>
<td>Sugars</td>
<td>2-4</td>
</tr>
<tr>
<td>Proteins</td>
<td>10-16</td>
</tr>
<tr>
<td>Polyphenols</td>
<td>10-20</td>
</tr>
<tr>
<td>Theobromine</td>
<td>2-3</td>
</tr>
<tr>
<td>Caffeine</td>
<td>0.1-0.7</td>
</tr>
<tr>
<td>Acids</td>
<td>0.30</td>
</tr>
</tbody>
</table>

For more details about the macronutrient composition of cocoa beans, see Appendix 1.

3.1.1 Organic acids
The most common organic acids in cocoa beans are citric, oxalic, malic, acetic, and formic acid with the most important one being acetic acid because of its influence on the taste of cocoa. The amount of acetic acid in the beans is affected by the degree of fermentation and drying. Also the geographical origin is an important factor in regards to the acid content and composition of the beans which is shown in Table 3 below (Bertazzo et al., 2013).
As seen in Table 3 cocoa beans from e.g. PNG have more than double the content of acetic acid as well as total acids compared to West African beans. The content of citric acid on the other hand is much lower in the PNG beans compared to the other regions.

### 3.1.2 Polyphenols and Alkaloids

Polyphenols make up 10-20% dry weight of the nib. These are the compounds which cause the astringency in cocoa. There are three groups of polyphenols in cocoa beans: catechins or flavan-3-ols, anthocyanins and proanthocyanidins. Pigmentation in polyphenolic storage cells ranges from white to deep purple among different cocoa varieties depending on the content of anthocyanins. Reactions between polyphenols and sugar and amino acids contribute with flavour and colour to cocoa beans. During fermentation the content of polyphenols is modified. Polyphenols are degraded by polyphenol oxidase which results in a decrease of the amount of flavonoids. In the final chocolate the amount of polyphenols depends on the percentage of cocoa solids which explains why the concentration of polyphenols is higher in dark chocolates than in milk chocolate. The alkaloids found in the polyphenolic cells include caffeine, theobromine and theophylline. These compounds are contributing to the bitter taste of cocoa, especially theobromine owing to its low taste detection threshold (Bertazzo et al., 2013; Afoakwa, 2010; Ziegleder, 2009).
3.2 Genetics and Origin
The most fundamental factor for the flavour potential is the genetics of the cocoa tree which determine the presence of specific flavour precursors as well as the activity of enzymes. As cocoa trees cross pollinate readily many cocoa trees today are hybrids of different genetics and it can be difficult to determine the exact genetics and quality of the beans without the help of DNA testing. Nevertheless, there are three genetic types of cocoa which are used for chocolate production. These are Criollo, Trinitario and Forastero and within these three types there are several genetic varieties (Fowler, 2009; FCIA, 2013b).

3.2.1 Cocoa Types
**Criollo** beans are the finest type of cocoa (WCF, 2013). The beans are generally recognized by their light colour and white nibs (Felperlaan, 1997). The flavour is generally mild with a nutty cocoa character. Criollo beans also tend to produce a more astringent chocolate than other varieties which is due to the high levels of procyanidins. However, these beans are susceptible to diseases and therefore produce low yields. Pure Criollo beans are now very rare and are only found in old plantations in Venezuela, Central America, Madagascar, Sri Lanka and Samoa. Most Criollo varieties used today are therefore hybrids (Fowler, 2009; Saltini, Akkerman & Frosch, 2013).

**Forastero** beans on the other hand, are more robust and can be produced in high quantities. This genetic type makes up about 90% of the world's production and is mainly grown in West Africa and Brazil (WCF, 2013). The colour of the beans is generally darker with purple nibs. The flavour is typically more bitter and less astringent and acidic than chocolate produced from other bean varieties (Fowler, 2009; Saltini, Akkerman & Frosch, 2013).

**Trinitario** beans are hybrids between Criollo and Forastero and have a light colour like Criollo beans (Fowler, 2009). This type is the most likely kind of cocoa to be found in high-quality dark chocolate today (The Chocolate Revolution, 2013a). Trinitario beans are known to have strong basic chocolate characters and winery flavour notes that are not found in other cocoa types (Saltini, Akkerman & Frosch, 2013).

In addition to these three genetic variants there is also one known as **Nacional**. However, this type is only grown in Ecuador and is not widely used. Nacional is considered as a special type of Forastero which produces fine flavour cocoa with a so-called ‘Arriba’ flavour. This flavour is characterized by floral, spicy and nutty aromas (Fowler, 2009; ICCO, 2013a).
3.2.2 Fine Flavour Cocoa

The cocoa market distinguishes between two broad categories of cocoa i.e. premium cocoa known as ‘fine flavour’ cocoa and ordinary cocoa known as ‘bulk’ cocoa (ICCO, 2013a). Fine flavour cocoa is produced from heirloom cocoa genetics, mainly obtained from Criollo or Trinitario varieties but in some regions it can be obtained from a genetic blend. Fine flavour cocoa yields premium prices due to its distinct flavour characteristics which include fruity, raisin, floral, spicy, acidic, and earthy and it is therefore mainly used to produce dark chocolate in which the special flavours can be appreciated. This cocoa is typically used by small bean-to-bar operations to produce premium chocolates such as single-origin chocolates. Bulk cocoa on the other hand is cheaper and is therefore most often used in the production of mass-produced chocolate products. Bulk cocoa is generally characterized by a strong cocoa flavour with low acidity and aromatic flavours. To achieve a large volume of a consistent end-product this cocoa is often a blend of beans from different geographical regions. Most of the bulk cocoa originates from West Africa and is typically obtained from Forastero varieties (ICCO, 2007; Fowler, 2009).

The International Cocoa Agreement (1993) has identified eight countries as exclusive producers of fine flavour cocoa. These include Dominica, Grenada, Jamaica, Saint Lucia, Saint Vincent and the Grenadines, Samoa, Suriname, and Trinidad & Tobago. Furthermore, some countries have been identified as partly producers of fine flavour cocoa. These include Ecuador, Venezuela, Costa Rica and Colombia. Ecuador is the world’s largest supplier of fine flavour cocoa and accounts for over half of the total production. Today, other typical growing regions of fine flavour cocoa include São Tomé and Principe, Sri Lanka, Brazil (Bahia), PNG, and Madagascar. The Latin American and Caribbean region supplies approximately 80% of the world’s fine flavour cocoa, followed by Asia and Oceania (18%) and Africa (2%) (ICCO, 2007).

Although fine flavour cocoa must possess distinct flavour characteristics no clear definition of fine flavour cocoa exists. Due to variations among bean varieties, origin and growing conditions cocoa beans can possess around 500 different flavours that can be distinguished by the human palate which makes it difficult to agree on a definitive definition of fine flavour cocoa. According to the PNG Cocoa bean Export Standard however, acceptable cocoa quality standard means the absence of flavour defects such as smoke taint, mouldy flavours and astringency which can potentially mask the fine flavour attributes of the cocoa beans and thus affect the export prices. Issues with smoke taint have resulted in PNG currently having 90% fine flavour status (PNG Cocoa Industry, 2013; Afoakwa, 2010).
3.2.3 Geographical Origin
Besides the influence of genetics the flavour formation is highly influenced by the origin of the cocoa and variations may therefore exist between the same type of cocoa from two different regions. This variation is due to differences in growing conditions including climate, sunshine, rainfall, soil conditions, ripening, and time of harvesting which all affect the flavour potential and development (Afoakwa, 2010). Some cocoas are therefore known and appreciated not only by the genetics but also by the origin of the cocoa as for instance Venezuelan Criollo and Ecuadorean Nacional (Felperlaan, 1997).

Flavour characteristics of specific regions
According to the literature, the Bahia region in Brazil is known to grow fine flavour cocoa which is generally characterized as being bitter, smoky, acidic, and astringent (Afoakwa, 2010), whereas cocoa from Madagascar, according to several chocolate experts, is generally recognised for its strong fruity notes. Most of the cocoa from Madagascar is mainly from the Criollo and Trinitario varieties and is generally used to produce premium chocolates (Bahen & Co, 2013b; Amano Artisan Chocolate, 2010; The Chocolate Revolution, 2013b).

Cocoa from Asia and the Oceania are known to possess a variety of flavour characters ranging from intense cocoa and nutty flavours to acid and phenolic notes. Cocoa from PNG for instance is appreciated for its very fruity taste and undertones of spice and smoke. The fruity flavours can range from citrus fruit to notes of raisin even within the same plantation. PNG is also known to produce cocoa with a high level of acidity compared to other regions, cf. Table 3 (Afoakwa et al., 2008; The Chocolate Revolution, 2013b).

West African cocoa beans are generally known to have a strong cocoa flavour with nutty undertones and low levels of aromatic flavours and acidity (Afoakwa, 2010). This has been proven in several studies. For instance, a study by Jinap et al. from 1995 showed that chocolates from West Africa (Ghana and Nigeria) had a more pronounced cocoa flavour and lower acidity compared to chocolates from other regions including Brazil, Indonesia, Dominican Republic, and Ecuador (Jinap, Dimick & Hollender, 1995).
### 3.3 Post-Harvest Flavour Formation

Despite the fact that flavour characteristics naturally vary among different cocoa beans, post-harvest processes such as fermentation, drying, and roasting have great influence on the flavour development. During each of these processes different reactions take place which result in formation of various flavour compounds (Afoakwa, 2010). Figure 1 below illustrates the major influential and determining factors for chocolate flavour formation.

![Diagram showing the major influential and determining factors for chocolate flavour development](image)

It is important that each of these processes are highly controlled in order to achieve an optimal flavour formation and to avoid undesirable flavour notes such as tobacco, excessive bitterness and astringency, mouldy, hammy and smoky. These off-flavours are usually caused by incorrect farming practices and are difficult to eliminate during further processing. The exact biochemical and chemical processes of chocolate flavour formation are not fully understood but some of the important factors and reactions during post-harvest processes will be described in the following (ICCO, 1998; Afoakwa et al., 2008).
3.3.1 Farming practices
Freshly harvested cocoa beans do not contain compounds necessary for the development of chocolate flavours. If the fresh beans are dried without fermentation, the nib will have a greyish colour rather than a brown colour, and it will not be able to develop the desired flavours during processing. Chocolate made from unfermented beans will taste very bitter and astringent. Fermentation and drying are therefore essential for the flavour formation, and these processes are normally carried out on the farms (Fowler, 2009; Ziegleder, 2009).

Fermentation
Different fermentation techniques are used for fermenting cocoa beans depending on farmers, areas and countries. The most common fermentation methods are platforms, heaps, baskets and wooden boxes (Saltini, Akkerman & Frosch, 2013). During fermentation the beans must be turned every second day to ensure uniformity. The wet cocoa pulp is infected by multiple types of airborne microorganisms from the environment, workers hands, tools etc. The sugar content of the pulp is 10-15% which causes the microorganisms to multiply and break down the sugars and mucilage (Fowler, 2009). Within the first couple of days, anaerobic yeasts convert the sugar compounds into alcohol and carbon dioxide. This gives rise to formation of acetic acid which causes the acidic taste of cocoa. When ethanol and acetic acid penetrate into the nibs it creates an acidic environment and a rise in temperature which leads to a damaged internal structure and eventually death of the cocoa bean (Camu et al., 2008). During fermentation, lactic acid bacteria become more dominant and convert sugars and organic acids into lactic acid. Once the pulp has decomposed, the beans come in contact with oxygen which leads to a colour change of the beans and reduction of astringency. Alcohol is converted into acetic acid which becomes more significant towards the end of fermentation where acids, esters, alcohols, aldehydes, ketones, and pyrazines are the most important groups of volatile compounds (Fowler, 2009; Rodriguez-Campos et al., 2011).

The optimal length of fermentation varies among different beans. Criollo beans for instance only require 2-3 days of fermentation for full development of the flavour precursors whereas other beans require longer time. However, most cocoa beans are fermented for approximately 5-6 days (Ziegleder, 2009). Studies have shown that a longer fermentation process does not improve the flavour potential of the cocoa beans. Contrarily, it might result in moulds growing in the beans and hence affect the quality (Saltini, Akkerman & Frosch, 2013). Over-fermentation can also result in a hammy off-flavour which can be difficult to distinguish from a smoky off-flavour (Ziegleder, 2009).
The quality of fermentation can be revealed by a cut test where the beans are cut in half as shown in the picture below. If the beans have been properly fermented the inside of the bean should be relatively dark and have a fishbone structure (Bahen, M., 2013, pers. comm., 12 Feb).

Drying
After fermentation, the beans are usually spread out in layers on mats, trays or a terrace on the ground and dried in the sun (Fowler, 2009). The moisture content must be reduced from 45% to around 7% in order to prevent mould growth during storage. This usually takes about 5-7 days of sunny weather (Camu et al., 2008). In areas with less sunshine at harvest time, other drying methods are used such as solar drying or artificial drying. Several studies that have compared natural and artificial drying methods conclude that natural sun drying gives a better result (Saltini, Akkerman & Frosch, 2013). The risk of using artificial drying is that the beans may be dried too quickly which will develop very acidic beans because the volatile organic acids are trapped inside the bean. Contrarily, in case the beans are dried too slowly the result is low acidity, poorer colour and high presence of moulds. Another problem with artificial drying is that smoke may come in contact with the beans and result in a harsh or smoked off-flavour which cannot be removed from the final chocolate. It is also important not to over-dry the beans. If the beans are dried to below 6% moisture they become brittle and are easily damaged during subsequent handling (Fowler, 2009; Saltini, Akkerman & Frosch, 2013).

During drying a non-enzymatic browning of the cocoa beans takes place. The reaction is also known as the Maillard reaction which is caused by a reaction between compounds with free amino groups such as amines and amino acids and reducing carbonyl compounds such as aldehydes and ketones. During the Maillard reaction several flavour precursors are formed which interact and result in development of several cocoa flavour compounds including alcohols, esters, aldehydes, and furans (Noor-Soffalina et al., 2009).
3.3.2 Chocolate Manufacturing Process
After the farming processes, the beans are packed and shipped to the respective chocolate producers for further processing. The production of chocolate varies between different producers depending on the desired end-product but at Bahen & Co. the process comprises of following steps: Roasting → winnowing → grinding and refining → conching → tempering.

Roasting
The cocoa beans are roasted slowly at low temperatures in a Barth Sirocco Ball Roaster from 1930. The beans are usually pre-dried in the roaster at around 80°C to reduce the water content below 2%. This will prevent a cooked and flat aroma in the beans. Subsequently, the beans are roasted at around 105°C for 20-40 min. The time and temperature of the roasting vary among different beans and batches depending on several factors such as moisture content, size of the beans, and flavour compounds. Finding the right roasting time and temperature is very important for the taste of the chocolate. If the beans are not roasted enough they tend to be very bitter whereas if they are roasted for too long, burned and off-flavours may develop.

High roasting temperatures can also destroy some of the fruity flavour compounds. Forastero beans, which start with a higher level of bitterness and generally lack fruity flavour notes, can therefore be roasted at higher temperatures than other beans (Bahen, J., 2013, pers. comm., 12 Feb; Saltini, Akkerman & Frosch, 2013).

During roasting the flavour precursors interact and produce the desired cocoa flavour. Both physical and chemical changes take place. The beans are cracked and the nubs become darker in colour. When the moisture content is reduced to below 2% most of the microorganisms are killed. Some of the volatile acids including aldehydes, ketones, pyrazines, and esters which contribute to acidity and bitterness are lost during roasting whereas fats, polyphenols and alkaloids only undergo minimal changes. The Maillard reaction also takes place during roasting. Amadori compounds which are the first intermediates of the Maillard reaction are highly reactive and are decomposed into several flavour volatiles which contribute to the development of an intense cocoa flavour (Afoakwa, 2010; Ziegleder, 2009).
Winnowing
After roasting the beans are transferred into a winnower that cracks the beans and separates the husk (shell) from the nibs. The winnower at Bahen & Co. is around 100 years old and was recovered from an abandoned chocolate factory in Latin America. The husk which is basically a waste-product is collected and used for beer production at a local brewery in Margaret River. The nibs are collected for further processing (Bahen, J., 2013, pers. comm., 12 Feb).

Grinding and refining
The cocoa nibs are stone ground in a Guitart Melangeur from 1910 and mixed with organic cane sugar. The machine slowly grinds and refines the nibs and sugar into a rich chocolate paste. During grinding heat treatment is generated which causes the cells of the beans to release the cocoa butter and melts into liquor. The viscosity of the liquor depends on the degree of roasting and on the moisture content of the nib. The process takes about 8 hours and results in a smooth and thick cocoa mass with a small particle size between 18 and 22μm. The particle size influences viscosity and texture and is therefore important for the rheological and sensory properties of the final chocolate. In general the maximum particle size of chocolate should be 30μm, as chocolate with a bigger particle size will be perceived as gritty or coarse in the mouth. Chocolates with a particle size around 20μm will thus have a smoother texture (Bahen, J., 2013, pers. comm., 12 Feb).

Conching
After grinding and refining the chocolate mass is conveyed to the Carle & Montanari Conche where it is polished between granite stones. The purpose of conching is to reduce viscosity which results in a more pleasant mouthfeel of the final chocolate. Furthermore, conching will remove undesirable flavours and simultaneously develop more pleasant flavour notes. Most chocolate manufacturers are using a conching temperature around 70-82°C for a few hours for dark chocolate. However, at Bahen & Co. temperatures are kept as low as possible throughout the
process for optimal flavour development. The chocolate is therefore usually conched at 40°C for up to 48 hours depending on the fat content of the cocoa mass and the drying process of the beans (Bahen, J., 2013, pers. comm., 12 Feb). During conching the moisture content is reduced and undesirable volatiles such as acetic acid are removed which decreases the acidity of the chocolate. Conching also promotes a re-distribution and further development of the flavour compounds because of the prolonged mixing at elevated temperatures. The flavour compounds and the fat are partially transferred to the sugar surface which result in a more homogeneous aroma perception. Some manufacturers add extra cocoa butter and lecithin to the chocolate mass towards the end of conching to achieve a thinner chocolate before tempering (Afoakwa, 2010; Ziegleder, 2009).

**Tempering**

Tempering is the last step of the production. This process affects the colour, shape, glossiness, hardness and shelf-life of the final chocolate. Tempering contributes to a smooth and firm texture. Un-tempered chocolate will have a soft texture and not be effectively de-moulded. The process of tempering starts with a complete melting of the chocolate at 50°C and subsequently cooled down to 30°C where the fatty acids will crystallise and set the form of the chocolate (Bahen, J., 2013, pers. comm., 12 Feb).

The cocoa butter can crystallise into six different polymorphic forms (I-VI) depending on how well the chocolate is tempered. The fatty acids crystallise in a double- or a triple-chain depending on the composition of the triglycerides. Form I-IV crystallises in a double-chain form whereas Form V and VI crystallises in a triple-chain system which enables tighter packing and a better thermodynamic stability. Form VI is most stable and has a high melting temperature of 36°C. Form I will rapidly convert into Form II which slowly transforms into Form III and IV. Form V is generally the most desirable form which gives the chocolate a glossy appearance and resistance to bloom. Fat bloom occurs when the fat transforms from unstable to stable crystallisation forms or as a result of exposure to sunlight or higher temperatures (Afoakwa, 2010).

The process from roasting to tempering takes around 48 hours. After tempering the chocolate is stored in big blocks in a cool room at 13°C for approximately three months. The long storage time enhances the desired flavours in the chocolate. After three months of storage the chocolate is remelted and moulded into bars of 75 grams, hand wrapped and packed for distribution (Bahen, J., 2013, pers. comm., 12 Feb).
4.0 Theory on Food Choice and Preferences

4.1 Properties of Chocolate

Chocolate seems to be more widely craved and more preferred than any other sweet food product and the tendency is especially seen among women who tend to like chocolate more than men. The high liking for chocolate may be explained by its appealing sensory characteristics, especially flavour and texture which are the most determining sensory attributes of chocolate in regards to preference. As mentioned earlier, chocolate flavours are very complex and differs widely among chocolate products. Texture relates to how the chocolate feels in the mouth when biting and chewing it and is therefore also important for the sensory perception. Chocolate with a low cocoa content (milk chocolate) is generally characterized as melting and creamy whereas chocolate with a higher cocoa content (dark chocolate) is often characterized as dry, mealy and sticky. Generally, a firm solid texture that melts easily in the mouth and a smooth mouthfeel are considered desirable textural characteristics of chocolate (Afoakwa, 2010; Thamke, Dürrschmid & Rohma, 2009).

Chocolate is high in both sugar and in fat, a combination that seems to be of particular appeal and may explain the general high liking of chocolate (Rozin, Levine & Stoess, 1991). Humans are born with a preference for sweet taste and fatty textures which ensures that infants like the sweet and fat breast milk (Hausner, 2007). Hence, the brain is already from birth coded to seek instinctive satisfaction and like sugar and fat containing foods which fulfils the body’s need for quick and longer lasting energy (Drewnowski, 2002). Dark chocolate on the other hand is also often characterized by a bitter taste which is inertly disliked. The predispositions of tastes however are readily altered via experience with food and eating throughout childhood (Birch, 1999) but it may explain why children generally prefer sweeter food products than adults and preference for bitter taste usually develops with age (Standen-Holmes & Liem, 2013).

Apart from the sensory properties it has been speculated that some of the biologically active substances in chocolate may have addictive and arousing properties and cause chocolate “cravings”. Most prominently, chocolate contains the methylxanthines, theobromine and caffeine. Theobromine seems to have addictive effects similar to those of caffeine, although theobromine is less stimulating. An interesting fact is that coffee, chocolate and tea are the most consumed products in the world and they are the also the three main dietary sources of methylxanthines (Rozin, Levine & Stoess, 1991).
Furthermore, chocolate contains biogenic amines including 2-phenylethylamine that tend to have arousing and mood-altering effects. Due to its structural similarity to amphetamine this compound induces the uptake and release of nor-adrenaline, dopamine, and serotonin and has therefore been considered as one of the bioactive compounds responsible for chocolate cravings (Bertazzo et al., 2013). However, the mood-altering effect may occur merely because eating chocolate is pleasurable, and several studies have also concluded that the biologically active substances have little or no effect on chocolate “addicton”. The most widely consumed types of chocolate are milk chocolate and chocolate-covered confectionery, and compared with dark chocolate these have a lower cocoa content and therefore also a lower concentration of the bioactive compounds found in cocoa. Therefore, it is more likely that chocolate cravings are confounded with preferences for sweet taste and fatty textures (Rogers & Smit, 2000).

### 4.2 Food Choice and Acceptance
Food choice is predominantly a learned and dynamic behaviour which is influenced by numerous factors such as cultural background, the surrounding environment, norms and habits, product properties, educational and socioeconomic factors, biological and physiological factors as well as other personal and cognitive aspects. All these factors influence personal preferences which most often determine the choice and intake of food. Several theoretical models have been proposed to illustrate the various factors that influence food choice and preferences. Most of the models are related to general food choice and are fairly similar, although they differ in emphasis (Shepherd & Sparks, 1994). However, the model of affection-related chocolate choice (MARCC) below has been developed to explain the important factors affecting chocolate intake specifically.

![Conceptual model of affection-related chocolate choice (MARCC)](image_url)

**Figure 2:** Conceptual model of affection-related chocolate choice (MARCC) (Januszewska & Viaene, 2001)
The MARCC model was developed in relation to a study by Januszewska and Viaene (2001) in which consumers’ preferences for plain chocolate in Belgium and Poland was compared. The concept of the model is based on the theory that three dimensions influence behaviour in regards to intake of plain chocolate; the affective dimension which includes preferences, overall liking and the sensory stimuli of the chocolate, the cultural dimension which includes the psychological traits of the individual and the external environment, and the demographic dimension which includes factors such as gender, age, and income. The core of the MARCC model relates to the expected and actual liking as well as the physiological state of the individual at the moment of food choice or consumption. These factors determine the individual’s attitude towards the chocolate which leads to a certain food choice behaviour (Januszewska & Viaene, 2001).

The MARCC model and most other food choice models are based on the fact that product information such as price, brand, label information and packaging is available to the consumer. This forms certain expectations and attitudes towards the product which influence preferences already before the actual food choice. Knowing that a chocolate is high quality, single-origin or organic may thus influence preferences. The strong influence of brand and label information on consumer acceptability was also shown in a study by Torres-Moreno et al. (2006) who found that premium chocolate brands generated higher expectations of liking than mass-produced brands. Nevertheless, the study showed that hedonic liking depended mostly on the sensory characteristics of the chocolate (Torres-Moreno et al., 2012). Liking is a major determinant of preference and is therefore a very important aspect of food choice (Ogden, 2003; Rozin, 2006). People are not uniform and it is difficult to understand why individual differences in liking exist. Furthermore, people are not consistent in their choices as preference changes throughout life (Köster, 2003). Food choice can therefore be difficult to predict theoretically. Several psychological theories on the dynamics of hedonic liking have been proposed. Some of these theories will be discussed below.

### 4.2.1 Exposure theory

Humans have a natural fear of novel foods, a concept also known as neophobia. At the same time humans need to consume a variety of foods to get all the essential nutrients that the body needs in order to function. This paradox is called “omnivore’s paradox”. Young children will therefore naturally avoid and dislike unfamiliar food but they must learn to accept it (Ogden, 2003). A hypothesis on how acceptance and liking is acquired is the theory of mere exposure by Robert B. Zajonc (1968). According to Zajonc, repeated exposure of a stimulus to an individual is a sufficient condition for enhancing liking for that stimulus. Hence, the change in affect does not depend on factors such as familiarity but are solely related to the history of exposures.
The theory however requires that no negative consequences are associated with the exposures (Zajonc, 1968). The mere exposure effect has been demonstrated mainly with visual and auditory stimuli while few studies have been performed with gustatory or olfactory stimuli. The hypothesis was tested with novel foods for the first time by Pliner in 1982. The study was conducted on 24 students at the University of Toronto where unfamiliar tropical juice was used as stimulus. The study demonstrated positive changes in liking after repeated exposure (Pliner, 1982). Another study on the theory with food products was conducted with 2 year-old children over a six-week period and these results also showed a direct relationship between exposure and preference. This study indicated that a significant shift in liking happens after 5-10 exposures (Birch & Marlin, 1982).

4.2.2 Boredom theory
Other psychologists who have tested the effect of repeated exposure on hedonic value have found contradictory results. Studies have shown that the theory only holds for certain stimuli. A study by Berlyne (1970) showed that whilst the hedonic value of complex stimuli tends to increase as they become less novel the opposite holds for simple stimuli (Berlyne, 1970). This is also supported by results from a study by Lévy & Köster (1999) which showed that repeated exposure to a simple stimulus led to boredom (indifference in liking) rather than to increased liking. Also in this study the mere exposure effect was only seen when the stimulus initially was perceived as complex (Lévy & Köster, 1999). A slowly rising aversion may also occur after repeated exposure towards a product that was initially well liked and lead to dislike of the product (Köster & Mojet, 2007). The studies by Berlyne and Lévy and Köster indicate that the more experience people get with a range of stimuli, the less likely they are to favour to the most familiar and initially most liked one. The explanation for this may be a reduction of neophobia or avoidance of boredom, or the changing perception of novelty and complexity (Lévy & Köster, 1999). The findings of both studies indicate that people continuously strive for variety and complexity which are in accordance with the arousal theory of Berlyne described below.

4.2.3 Arousal theory
Berlyne’s arousal theory (1967) was based on Hebb’s (1949) idea that the individual strives to maintain an optimal level of activation as well as Berlyne’s own experiments on curiosity and exploratory behaviour. Berlyne assumed that exploratory behaviour is usually accompanied by increased arousal. He distinguished between two types of exploratory behaviour: specific and diverersive exploration. Specific exploration is based on uncertainty about the stimulus characterised by an aversive condition where the behaviour is directed at resolving the uncertainty and thus
reducing the arousal. Diversive exploration on the other hand is a result of boredom and monotony and is directed at increasing arousal level to the individual’s optimal level by seeking stimulation from other sources. This behaviour often sets in just after specific exploration is completed and the uncertainties are resolved (Köster & Mojet, 2007). Berlyne thus proposed that if a stimulus is below the individual’s optimal arousal level it will lead to arousing seeking behaviour whereas if a stimulus is above optimal arousal level it will lead to arousing avoiding behaviour. People have different levels of optimal arousal which explains why the same stimulus might have different effects in different individuals. Previous experiences influence preference and how people interpret different things and it has been hypothesised that experts generally search for new stimuli more than non-experts. Nevertheless, the more a stimulus deviates from an individual’s optimal arousal level the less it will be liked by this individual. The arousal potential of a stimulus can be defined as the set of properties that determine the individual’s level of arousal. These include the so-called ‘collative’ properties which relate to an individual’s previous experiences and comparisons of different stimuli (Lévy, MacRae & Köster, 2006). According to Berlyne, novelty and perceived complexity are important collative properties for changes in hedonic liking as the perception of these properties changes with repeated exposure to a stimulus. The relationship between hedonic value and arousal potential is illustrated by the Wundt Curve in Figure 3.

![Wundt Curve](image)

Figure 3: The Wundt Curve (Berlyne, 1970)

The figure shows that the hedonic value is rather low when a stimulus is perceived as simple and familiar. This depicts product boredom which may be a result of repeated or prolonged exposure to a stimulus. As arousal potential increases, the hedonic value becomes greater and liking is highest when the stimulus has simple, complex, novel, and familiar characteristics. However, as arousal potential increases further and a stimulus is high in perceived complexity and novelty, liking
decreases and becomes negative. This tendency leads to prediction of an inverted U-shaped function between hedonic value and arousal potential (Berlyne, 1970).

The theory thus predicts that in order for a new food product to be liked it must have elements of both novel and familiar characteristics without being too complex. This is also in compliance with the MAYA principle (Most Advanced - Yet Acceptable) proposed by Raymond Loewy in 1951. Even though the principle was initially demonstrated in regards to industrial designs it illustrates a general conflict between neophobia (fear of new things) and neophilia (liking of novel things). Even though novelty and familiarity are negatively correlated most people tend to like familiar things but at the same time have a desire and curiosity for new things (Hekkert & Leder, 2008).

In addition to Berlyne’s arousal theory, Dember and Earl (1957) have proposed the theory that an individual’s optimal arousal level is not stable but will increase by exposure to stimuli that are perceived as slightly more complex than the optimally preferred one. According this theory perceived complexity is the most important collative property for arousal potential. After novelty is reduced by exposure perceived complexity dominates the arousal potential of the stimulus. Exposure to a stimulus that is a little more complex than optimal, a so-called ‘pacer’, will lead to a change in liking of all stimuli and pleasantness of the originally most liked stimulus will decrease. As perceived complexity of a stimulus decreases, appreciation for more complex stimuli will increase. This will change the individual’s optimum arousal level. Stimuli with lower than optimal arousal potential on the other hand will be perceived as boring and will not alter the optimal arousal level. Dember and Earl thus concluded that any change in preference would be from less to more complex stimuli which is illustrated in Figure 4 (Lévy, MacRae & Köster, 2006).

In addition to Berlyne’s arousal theory, Dember and Earl (1957) have proposed the theory that an individual’s optimal arousal level is not stable but will increase by exposure to stimuli that are perceived as slightly more complex than the optimally preferred one. According this theory perceived complexity is the most important collative property for arousal potential. After novelty is reduced by exposure perceived complexity dominates the arousal potential of the stimulus. Exposure to a stimulus that is a little more complex than optimal, a so-called ‘pacer’, will lead to a change in liking of all stimuli and pleasantness of the originally most liked stimulus will decrease. As perceived complexity of a stimulus decreases, appreciation for more complex stimuli will increase. This will change the individual’s optimum arousal level. Stimuli with lower than optimal arousal potential on the other hand will be perceived as boring and will not alter the optimal arousal level. Dember and Earl thus concluded that any change in preference would be from less to more complex stimuli which is illustrated in Figure 4 (Lévy, MacRae & Köster, 2006).

Figure 4: Arousal theory by Dember & Earl. The relationship between liking and the arousal potential of a stimulus (solid curve), and the shift (dotted curve) in optimal level of complexity upon exposure to a 'pacer' (Lévy, MacRae & Köster, 2006)
The theory of Dember and Earl is in accordance with Walker’s (1980) explanation of the dynamics of liking and exposure. Walker showed that as stimuli become more familiar with repeated exposure they will be perceived as less complex which will result in a change in liking. However, the direction of the change depends on the perceived complexity of the stimuli compared to the optimal perceived complexity. For stimuli that are above the optimal level and too complex to be liked at first, liking will increase with repeated exposure whereas stimuli which are at the optimal level or below, will soon be perceived as too simple, and liking for them will therefore decrease. When the optimal level exceeds arousal potential the stimuli become boring (Lévy, MacRae & Köster, 2006; Köster & Mojet, 2007).

The predictions of Berlyne (1967), Dember and Earl (1957), and Walker (1980) can be combined into one theory which is illustrated in Figure 5 below.

![Figure 5: Illustration of the arousal theories of Berlyne, Dember and Earl, and Walker (Lévy, MacRae & Köster, 2006)](image)

Figure 5 shows the effect of repeated exposure to a stimulus on its perceived complexity and on its hedonic pleasantness. Product boredom and mere exposure effects (Zajonc) can be interpreted as a special case of this theory and are therefore included in the figure. According to Zajonc, repeated exposure to a stimulus is a sufficient condition to increase liking. In the arousal theories on the other hand, the increase in liking is dependent on the individual’s optimal level of psychological complexity, and the mere exposure effect is thus due to a decrease of perceived complexity.
The dotted line at the right in Figure 5 represents the theory of Zajonc. It shows that as exposure increases the points of the line get closer to the line that represents the optimal level of complexity (arousal) indicating that liking increases. At the same time it can be seen that this only holds for stimuli that are more complex than the optimal level of complexity. For all other stimuli repeated exposure leads to boredom. This illustrates the theory of Walker. The inverted U-shaped lines to the left in the figure represent the theories of Berlyne and Dember and Earl, respectively. The solid line shows the relationship between arousal potential and hedonic liking according to Berlyne, and the dotted line illustrates the shift of the optimum perceived complexity followed by exposure to a ‘pacer’ according to Dember and Earl (Lévy, MacRae & Köster, 2006).

4.2.4 Context

Another important aspect of food choice and preferences is the concept of context which has been studied extensively by Herbert L. Meiselman. Meiselman considers the interaction of the individual and the environment as critical in determining food choice. The same individual may have different food choice behaviours in different environments including physical as well as cultural and social surroundings. Different physical and cultural environments leave the consumer with different choices and norms which naturally influence food choice. Also, the meal setting and social context are important aspects of food choice and preferences. Perceptions of food vary depending on the context in which the food is consumed. In sensory evaluation food products are often tested individually in laboratory settings. However, food is normally consumed in natural settings and often as part of a meal which may alter the perception of the product. Furthermore, food is often consumed at social occasions where norms and habits play a large role and the social aspect for many people may be more important than the actual meal itself. Studies have shown that social facilitation during a meal increases the duration of the eating situation as well as the amount of food consumed which emphasize the importance of the social context. Moreover, different foods are generally appropriate at different times of the day or at different occasions which determines when and how often a food product is consumed. Appropriateness is therefore also important for food choice and perceptions (Meiselman, 2006).
5.0 Sensory Study
The sensory study of this thesis comprises of two parts in which different methods of both qualitative and quantitative nature have been used. As an initial step, a group of specialists has been recruited for a workshop with the aim of developing a vocabulary of chocolate descriptors and thus comprised the more qualitative part of the study. Subsequently, a consumer test has been conducted in which hedonic liking and descriptive profiles of the chocolate samples have been obtained by use of quantitative methods. This test comprises the main part of the study.

5.1 Specialist workshop
The purpose of the workshop was to elucidate flavour and mouthfeel descriptors of dark chocolate which were used as attributes in the descriptive consumer test. Several sensory descriptors of chocolate can be found in the literature, but as they represent a broad variety of chocolate products many of them may not be relevant for this study. Furthermore, the choice of attributes in a questionnaire is important since some sensory characteristics can have strong influence on consumer preference. Using a group of specialists was therefore considered being an effective method to obtain descriptors that were suited for this particular study. Even though the specialists did not receive any former training in sensory vocabulary generation they were considered to have great knowledge about chocolate and flavours and were thus found suited for the task (Lawless & Heymann, 2010).

5.1.1 Materials and methods
The workshop included a rapid profiling of eight dark chocolate samples followed by a group discussion. Two partial Napping exercises were chosen as the profiling method. Both Nappings were combined with an Ultra-Flash Profiling (UFP) which is commonly used to add a descriptive dimension to the Napping task (Reinbach et al., 2013). The two Nappings were restricted by sensory modality i.e. flavour and mouthfeel respectively. This method was considered as a good and quick way of finding relevant descriptors. In this way, it was possible to obtain the specialists’ spontaneous responses to the samples in addition to the group discussion. Furthermore, the method enabled the possibility to look at product differences and thereby validate the choice of samples for the consumer study.
Recruitment and Participants
The specialist group consisted of 7 participants, 2 men and 5 women, who were selected according to experience with chocolate and high quality food products as well as interest and availability. All participants were personally contacted and recruited by the researcher herself and Professor Garry Lee. The group included 4 chocolatiers, 1 pastry chef, and 2 participants from other food businesses. The participants were all working in small high-end food businesses which are well renowned in Perth for their gourmet products. Since all participants had experience in working with premium chocolate or other high quality food products they were assumed to have great knowledge about food flavours. Due to ethical reasons the identities of the participants are kept anonymous in this project.

To ensure optimal taste conditions and ability the participants were told not to eat, drink or smoke at least 30 min. prior to the tests and not to wear any perfume or cologne on the day of the workshop (Lawless & Heymann, 2010).

Samples
Eight different samples of plain dark chocolate with a cocoa content of 70-72% were used for the workshop. The samples were of different quality and included two single-origin chocolates from Bahen & Co. All the samples were purchased from stores in Perth. The reason for including samples of different quality was to enhance the likelihood that a broad range of relevant flavour and mouthfeel characteristics of dark chocolate would be represented. The number of samples was considered optimal for this exercise. It was important to have a certain variety of samples represented without reaching sensory fatigue among the panellists. Table 4 below provides an overview of the samples used for the rapid profiling.

Table 4: Overview of the samples used for the rapid profiling

<table>
<thead>
<tr>
<th>Bahen &amp; Co</th>
<th>Bahen &amp; Co</th>
<th>Gabriel Chocolate</th>
<th>Gabriel Chocolate</th>
<th>Margaret River</th>
<th>Lindt</th>
<th>Green &amp; Black’s</th>
<th>Cadbury</th>
</tr>
</thead>
<tbody>
<tr>
<td>70% Madagascar</td>
<td>70% Brazil (Bahia)</td>
<td>72% Madagascar</td>
<td>72% Venezuela</td>
<td>70% Gourmet Bar</td>
<td>70% dark Excellence</td>
<td>70% dark Organic</td>
<td>70% Old Gold</td>
</tr>
</tbody>
</table>

The samples from Bahen & Co. and Gabriel Chocolate are considered as comparable premium chocolates. Both producers are small Australian bean-to-bar operations located in the Margaret River region. They are both producing single-origin chocolates made with fine flavour cocoa which are sold at a high price, approx. 12 AUD/100g. The sample from Margaret River Chocolate Company is also locally produced although by a somewhat larger manufacturer, and sold as a gourmet chocolate at a relatively high price, 6.5 AUD/100g. These chocolates are only distributed in certain exclusive food stores, mainly in WA.
The last three samples (Green & Black’s, Lindt and Cadbury) are produced by large chocolate companies. They are all mass-produced chocolates which are sold in most supermarkets worldwide although they vary in quality. Green & Black’s and Lindt are branded as high quality chocolates and are sold at a similar medium price, 3-4 AUD/100g. Cadbury, on the other hand, is considered as bulk chocolate considering the fact that it is a relatively cheap chocolate (approx. 2 AUD/100g) and it is not branded as a high quality chocolate.

Test Location
The workshop took place in a venue at UWA. The room was located in the Science Library, and was free from outside noise. The room had a big table suited for 10 persons which enabled interaction among the participants. The room was temperature controlled and free from odours. The location was easily accessible with good parking facilities. Directions to the location were given via email and via signs in the library.

5.1.2 Experimental design and procedure
Sample preparation
The preparation of the samples took place in a kitchen close to the assigned test room. Two days before the workshop, the chocolates were cut up into smaller pieces of approximately 1x1cm to ensure homogeneous sample sizes, and brand names were erased from the surfaces of the chocolates using hot water and a knife. All samples were kept dry and stored at room temperature until the day of the workshop as the recommended serving temperature for chocolate is 18°C-21°C (Barry-Callebaut, 2013). The serving size was three pieces of each sample. The samples were served in white styrofoam containers and blind-labelled with random three-digit numbers to avoid any bias in regards to the chocolate brands from interfering with the results.

Palate cleansers
Warm water (40°C) and unflavoured crackers were used as palate cleansers. Furthermore, room-tempered mineral water was provided for thirst quenching and mouth rinsing during the test. The choice of palate cleansers was based on recommendations for sensory evaluation and previous research. Neutral table water crackers have been found to be the only effective palate cleansers across all foods (Lucak & Delwiche, 2009), and mineral water is commonly used for palate cleansing in sensory studies to get rid of residues from previous samples. Warm water however is considered to be more effective for palate cleansing than cold water for food products with a high fat content such as chocolate (Jinap, Dimick & Hollender, 1995; All Chocolate, 2013).
Workshop procedure
The workshop took place on April 15th 2013 with start at 10am. The session had a duration of 3h and 30min. After introducing the participants to the project, they were asked to present themselves one by one to the rest of the group. The purpose of the individual presentations was to make the participants feel more comfortable with each other and make everyone feel confident with speaking in the group (Lawless & Heymann, 2010). Next, the panellists were given verbal instructions about the Napping method. No information was given about the samples prior to the test to prevent bias. An example test using dried fruit samples was carried out before the actual test in order to make the participants familiar with the method. Each panellist was provided with a white A2 (60x40cm) blank paper sheet (Napping sheet), a pen, post-its, palate cleansers, cups for drinking and spitting, and a tray with the chocolate samples. The samples were presented simultaneously with a randomized order on each tray. The panellists were instructed to taste all of the samples one by one in the presented order and to cleanse their palates before and in between samples. The chocolate samples were evaluated by each panellist according to similarities and dissimilarities within each sensory category. Similar samples were placed close to each other on the Napping sheet whereas dissimilar samples were placed further apart on the sheet. Appropriate descriptors were noted on the post-its and placed next to the corresponding sample. The panellists were allowed to go back and forth between the samples during the test. When the final configuration was made the sample codes were noted on the sheet next to the corresponding samples and the placement of each sample was substituted with an X. A 15 min break was given in-between the two Napping exercises to reduce sensory fatigue. After the individual exercises the participants were asked to discuss the descriptors in the group. The descriptors were written on a whiteboard which enabled the group to discuss the meaning of the words and reach consensus on the terms. The group was also asked to consider other typical and important descriptors that may not have been present or detected in the given samples. In the end, each participant received a small gift for their time and contributions.
5.1.3 Data Analysis
The data from the two partial Nappings and UFPs was analyzed by qualitative and quantitative methods with the objective of finding relevant flavour and mouthfeel descriptors for the consumer test and investigating sample differences.

Pre-processing of data
The distances between the samples for each sensory modality were obtained by measuring the individual X and Y coordinates for all sample positions from the Napping sheets. The left bottom corner of each sheet was considered as origin of the coordinate system and in this way the X and Y coordinates for each sample could be determined and compiled in an Excel spreadsheet.

The descriptive terms obtained from the UFPs and the group discussion were also compiled in Excel and analysed qualitatively by the researcher herself. Due to the huge amount of data, the number of descriptors was reduced by eliminating words mentioned by only one of the panellists as well as words that were not considered relevant. The remaining descriptors were reduced further by grouping words of similar meaning or of the same category. In this way, a list of 18 flavour descriptors and 5 mouthfeel descriptors was developed. Table 5 below shows all the relevant descriptors and how they were grouped.

Table 5: Groupings of the relevant flavour and mouthfeel descriptors

<table>
<thead>
<tr>
<th>Flavour descriptors</th>
<th>Mouthfeel descriptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raisin</td>
<td>Drying</td>
</tr>
<tr>
<td>Red fruit</td>
<td>Tannic dry, astringent</td>
</tr>
<tr>
<td>Red wine, raspberry, cherry, red stone fruit</td>
<td></td>
</tr>
<tr>
<td>Yellow stone fruit</td>
<td>Crunchy</td>
</tr>
<tr>
<td>Apricot, peach, dried fruit</td>
<td></td>
</tr>
<tr>
<td>Fruity</td>
<td>Waxy</td>
</tr>
<tr>
<td>Citrus, sour</td>
<td>Soft</td>
</tr>
<tr>
<td>Fruity</td>
<td>Grassy</td>
</tr>
<tr>
<td>Burnt, black tea</td>
<td>Grainy</td>
</tr>
<tr>
<td>Roasted</td>
<td>Creamy</td>
</tr>
<tr>
<td>Spicy</td>
<td>Smokey</td>
</tr>
<tr>
<td>Cinnamon, liquorice</td>
<td>Smooth</td>
</tr>
<tr>
<td>Sweet</td>
<td>Silky, velvety</td>
</tr>
<tr>
<td>Sugar</td>
<td></td>
</tr>
<tr>
<td>Honey</td>
<td></td>
</tr>
<tr>
<td>Mouldy</td>
<td></td>
</tr>
<tr>
<td>Musty, dirty, old soil</td>
<td></td>
</tr>
<tr>
<td>Earthy</td>
<td></td>
</tr>
<tr>
<td>Blue cheese, woody, grassy</td>
<td></td>
</tr>
<tr>
<td>Tobacco</td>
<td></td>
</tr>
<tr>
<td>Cocoa</td>
<td></td>
</tr>
<tr>
<td>Deep chocolate, cocoa powder</td>
<td></td>
</tr>
<tr>
<td>Nutty</td>
<td></td>
</tr>
<tr>
<td>hazelnut, almond, pecan, brazil nut, walnut</td>
<td></td>
</tr>
<tr>
<td>Caramel</td>
<td></td>
</tr>
<tr>
<td>fudge, brown sugar, fairy floss burnt</td>
<td></td>
</tr>
<tr>
<td>Floral</td>
<td></td>
</tr>
<tr>
<td>Buttery</td>
<td></td>
</tr>
<tr>
<td>Fatty</td>
<td></td>
</tr>
</tbody>
</table>
The descriptors were listed in the Excel spreadsheets with the corresponding X and Y coordinates and each descriptor got a weighting factor specified by how many of the panellists who wrote the specific descriptor (or a word with similar meaning). In that way, it was possible to analyze the importance of each descriptor. The data tables were imported to the software program PanelCheck for quantitative analysis. The data was initially analysed by ANOVA to seek an overview of the panel performance by investigating product and assessor effects for all the descriptors. Subsequently, PCA was carried out to obtain an overview of the sample differences. The analysis included data from both the Napping method and the UFP which enabled analysis of the differences between the samples based on their individual placement on the Napping sheets as well as on the descriptive differences.
5.2 Consumer Study
The consumer test included an affective test and an analytical descriptive test. The objectives of the tests were to obtain hedonic responses and perceptions of collative properties towards the chocolate samples and to get a descriptive profile of each sample. Usually, an expert panel is preferred for analytical descriptive tests in order to obtain more accurate sensory profiles. However, training of a panel is very time consuming and costly compared to consumer tests, and due to the limited time frame and resources of this study it was decided to conduct both the affective and the descriptive test with consumers within the same test session (Moskowitz, 1996).

5.2.1 Materials and Methods
Consumer liking of each of the samples were measured on a 9-point hedonic scale. This scale is the most commonly used method for hedonic tests where untrained individuals are involved. Furthermore, perceptions of the collative properties ‘ordinary’, ‘novel’ and ‘high quality’ were measured on a 5-point Likert scale. This scale is commonly used to measure attitudes towards a product based on the degree to which the consumer agrees or disagrees with a statement. The scales were chosen due to their simplicity and ease of use in consumer studies (Poste et al., 1991; Lawless & Heymann, 2010). The collative properties were included in the test in order to investigate how these were correlated to consumer liking and to the different samples. The choice of properties was based partly on Berlyne’s arousal theory considering the effect of novelty on liking, and partly on the interest of studying how the consumers’ perceptions of high quality and ordinary varied between the premium and the mass-produced chocolates.

The descriptive profiles were obtained via the CATA-method. This method was also chosen due to its simplicity and yet high validity. In the present study, the traditional CATA-method has been modified in two ways. Instead of only ticking the words found to be descriptive for the samples the consumers were asked to check a ‘yes’ or ‘no’ box for each attribute. This modification was adopted in order to increase the likelihood that consumers would consider the whole list of attributes (Reinbach et al., 2013). Furthermore, the CATA-method was combined with 9-point intensity scales for each attribute. Since all the samples were 70% dark chocolates it was hypothesized that they had several flavour attributes in common, however the intensity could vary. The addition of intensity scales thus enabled the opportunity of higher discrimination between the samples.
Questionnaires
The design of the questionnaires was based on recommendations for sensory tests. In general the questionnaires and instructions were kept as short and precise as possible with use of plain language to avoid confusion. Furthermore, the layout was designed with a good visual appearance in order to make it easy to read and easy to fill out the score sheets. The order of the questionnaires was also carefully considered.

The first questionnaire covered the affective test and thus included the hedonic scale and three statements related to the collative properties with a Likert scale for each (Appendix 2). This questionnaire was intentionally put first in the test to induce the consumers’ immediate responses. The hedonic scale was assigned with numerical values from 1-9 with verbal phrases in the ends and in the middle. The scale was bipolar and ranged from ‘dislike extremely’ to ‘like extremely’ with a central point of ‘neither like nor dislike’. The Likert scale was a 5-point non-numerical category scale ranging from ‘strongly disagree’ to ‘strongly agree’.

The second questionnaire comprised the descriptive test (Appendix 3). The CATA-questionnaire contained a predefined list of flavour and mouthfeel attributes. All attributes were combined with numerical 9-point intensity scales with verbal phrases in each end ranging from ‘very weak’ to ‘very strong’. It was important that the attributes were easy to understand to increase the validity of the test. Examples were therefore given in phrases for some of the attributes. The attribute order in the questionnaire was randomized between participants as well as within participants to avoid response bias due to attribute order effects (Ares & Jaeger, 2013).

The last questionnaire contained participant background questions (Appendix 4). The questions included demographic variables such as gender, age, nationality, and annual income. Furthermore, questions were related to consumption patterns of chocolate and general interest in high quality food products in order to investigate if this had any impact on liking of the different samples. The choice of variables was based on common segmentation variables in consumer research as well as considerations of factors important for segmentation in regards to preference of dark chocolate (Meilgaard et al., 2007). The different income groups were based on recent income statistics for WA from the Australian Bureau of Statistics (ABS, 2013). This questionnaire was intentionally the last to fill out in order to avoid response bias as some questions may take on false importance and affect the consumer’s hedonic response (Lawless & Heymann, 2010).
Recruitment and participants

According to the principles for sensory evaluation, at least 50 consumers are needed for an affective test (Meilgaard et al., 2007). Furthermore, since more variance is expected from consumer data in descriptive tests, the consumer panel must naturally be larger than a trained panel in order to produce reliable results (Moskowitz, 1996). Based on practical and statistical considerations the aim was to recruit approximately 100 consumers for the test. It was desired to recruit people from different demographic groups in order to get a broad and representative group of consumers.

The recruitment took place in May 2013 during weeks 19 and 20. Flyers (Appendix 5) were used for advertisement and were distributed via physical and electronic channels. The physical distribution channels included local communities in Perth such as supermarkets, shops, restaurants, schools, libraries, and the campus areas of UWA and Curtin University. Facebook, emails, and the UWA postgraduate newsletter were used for electronic distribution. The participants were screened before the study by use of a screening questionnaire (Appendix 6) and recruited according to following criteria:

- Consumers of dark chocolate
- Absence of diabetes and other health problems
- Absence of food allergies
- No aversions to sweet and bitter
- Age (18-65)

Consumers in an affective test must be users of the products being tested in order to be representative of the target group. Therefore, only participants who were consumers of dark chocolate were included in the study. The other criteria were chosen based on ethical considerations and principles at UWA in regards to human research. To ensure enough participants for the study no further criteria were chosen. A small gift was guaranteed for participation and used as a token incentive to recruit as many consumers as possible. The recruitment resulted in more than 100 people showing interest and signing up for the test. The main part was students from UWA. A few were excluded because they did not meet the criteria and approximately 20 people did not return the screening questionnaire or cancelled before the test. A total of 88 consumers participated in the study, 38 men and 50 women. Nearly half of them were in the age group 18-25 and only 8 participants were above the age of 46. For optimal taste ability all participants were informed not to eat, drink or smoke at least 30 min. prior to the test (Lawless & Heymann, 2010).
**Samples**

Six different samples of plain dark chocolate were used in the consumer test. For comparable reasons, all the chocolate samples had a cocoa content of 70%. The decision of sample number was based on principles of good practice for sensory testing in which a maximum of 5-6 samples are recommended for consumer tests (Stone & Sidel, 2004). When intensity in flavour characteristics is evaluated several tastings of each sample may be necessary. A maximum of six samples was therefore chosen in order to avoid sensory fatigue and sensory-specific satiety (SSS) from influencing the responses. SSS is explained as a temporary decline in liking for a consumed food and motivation to eat more of it in comparison to other unconsumed foods (Havermans et al., 2009). Table 6 below provides an overview of the six samples used in the consumer study.

<table>
<thead>
<tr>
<th>Producer</th>
<th>Origin</th>
<th>Labelled Ingredients</th>
<th>Genetics</th>
<th>Fermentation</th>
<th>Drying</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bahen &amp; Co</td>
<td>Madagascar</td>
<td>Cocoa mass, organic raw sugar</td>
<td>Trinitario</td>
<td>Box, 5 days</td>
<td>Sun, 7 days</td>
</tr>
<tr>
<td>Bahen &amp; Co</td>
<td>Brazil (Bahia)</td>
<td>Cocoa mass, organic raw sugar</td>
<td>Forastero</td>
<td>Box, 6 days</td>
<td>Sun, 7-10 days</td>
</tr>
<tr>
<td>Bahen &amp; Co</td>
<td>Solomon Island</td>
<td>Cocoa mass, organic raw sugar</td>
<td>Forastero/Trinitario/Criollo</td>
<td>Box, 6 days</td>
<td>Sun, 7 days</td>
</tr>
<tr>
<td>Bahen &amp; Co</td>
<td>Papua New Guinea</td>
<td>Cocoa mass, organic raw sugar</td>
<td>Trinitario/Forastero/Criollo</td>
<td>Box, 7 days</td>
<td>Sun, 7-12 days</td>
</tr>
<tr>
<td>Green &amp; Black's</td>
<td>Dominican Republic/Belize</td>
<td>Chocolate Liquor, raw cane sugar, cocoa butter, soy lecithin, vanilla extract, whole milk powder</td>
<td>Trinitario</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Organic Cadbury</td>
<td>Ghana/Asia</td>
<td>Cocoa mass, sugar, cocoa butter, cocoa powder, flavour, milk solids</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Four of the samples were premium single-origin chocolates produced by Bahen & Co. These included the two prototype samples made with cocoa beans from the South Pacific i.e. Solomon Island and PNG, respectively. As seen in Table 6, the cocoa beans from these regions are a mix of different genetics whereas the cocoa from Madagascar and Brazil are of one single genetic type i.e. Trinitario and Forastero, respectively. According to Josh Bahen, the PNG cocoa is predominantly of the Trinitario type whereas the Solomon Island cocoa is primarily Forastero. As also shown in the table, similar methods for fermentation (box) and drying (sun) have been used for the cocoa beans from the four different regions, although the length of both processes varies (Bahen, J. 2013, pers. comm., 10 July).
The two additional samples, Green & Black’s and Cadbury, were included in the test to investigate how consumer preference varied between the premium chocolates from Bahen & Co. and two mass-produced chocolates. It was desired to find out if novelty and familiarity had an impact on preference and since it was assumed that at least one of these two chocolates would be familiar to a large part of the consumers it was considered relevant to include them in the study. Information about origin and type of cocoa used for these two chocolates has been obtained from the websites of the companies (Cadbury, 2013; Green & Black’s, 2013). Since more than one geographical region is listed for both of the chocolates the exact country of origin for each of these samples is not known and since none of the two chocolates are branded as single-origin, the cocoa may be a blend of beans from more than one region. As seen in Table 6 these two chocolates contain more ingredients than the premium chocolates such as flavours, milk solids and soy lecithin which differentiate these samples further from Bahen & Co.’s chocolates.

Test location
The consumer test was conducted as a central location test in a sensory laboratory setting (Resurreccion, 1998). The test sessions were held in different venues which were all geographically located at UWA. The venues were all easily accessible and signs were put up directing towards the chocolate tasting. The tests took place in rooms which could accommodate up to 20 people in one session. Temperature and humidity were maintained at a constant, and the test rooms were frequently ventilated. The sample preparation areas were neither visible nor physical accessible for the participants which reduced the chance of response bias. The method enabled a relatively high level of control and validity as the researcher was able to carefully manage and standardize sample preparation and servings (Lawless & Heymann, 2010).

5.2.2 Experimental design and procedure
The chocolate samples were prepared 2 days prior to the first test session using the same preparation method as for the specialist workshop, cf. paragraph 5.1.2. The serving size for the consumer test was 5 pieces of each sample. To ensure statistical validity a completely randomized design was used in which all samples were randomly assigned to the participants and blinded with random three-digit numbers. This design was fitted for this test since all the samples were evaluated by each consumer. Randomization prevented presentation order effects, especially first-position order effects and limited discussions about the samples between the panellists (Lawless & Heymann, 2010). The three-digit numbers and the randomization scheme were calculated in the statistical software programme FIZZ.
The study was conducted from Tuesday to Friday in week 21, May 2013. The study included a total of 5 sessions which were held at 10am, 11am, and 5.30pm respectively with a maximum of 20 people per session. Each session lasted around 45 minutes. The test times were chosen according to availability of the venues and to avoid testing just after meals. The study was carried out considering the principles of good practice for sensory evaluation (Lawless & Heymann, 2010).

When the participants arrived they were seated and welcomed. Each participant was provided with a folder containing the questionnaires, a pen, and palate cleansers. The participants were instructed to cleanse their palates in between each sample. Due to practical reasons warm water was not provided for this test and thus only unflavoured crackers and room tempered mineral water were used for palate cleansing. The instructions and procedures for the test were given verbally before the test started. In addition, all participants were provided with an instruction sheet (Appendix 7) in order to make the test as simple and clear as possible and in that way reduce the risk of misunderstandings. No information was given about the samples to avoid bias. Thereby, the participants could generate their own personal opinion about the samples.
The samples were served one by one to each participant and they were instructed to fill out all the questionnaires for each sample before a new sample was served. In the first questionnaire the participants were required to rate their overall liking/disliking of the sample on the 9-point hedonic scale and furthermore to rate their level of agreement/disagreement with the three statements related to the collative properties on the 5-point Likert scale. Next, they were required to fill out the CATA-questionnaire and evaluate the sample on each of the flavour and mouthfeel attributes listed in the questionnaire. The participants were instructed to tick the ‘yes’ box if an attribute was found appropriate/describing for the sample and to tick the ‘no’ box if an attribute was not describing for the sample. Furthermore, the intensity of all the appropriate attributes was rated on the 9-point intensity scale.

After the last sample was evaluated the consumers were required to fill out the questionnaire with participant background information. At the end of the test each participant was given the token incentive which was a premium chocolate bar from Bahen & Co. Chocolate.
5.2.3 Data Analysis
This part will describe how the data from the consumer study was pre-processed and analysed with the aim of investigating preference patterns, sensory profiles, and co-variance among various types of data.

Pre-processing of data
The raw data from all the questionnaires was computed in Excel into three different spreadsheets, one sheet containing all the sensory data (CATA-intensity scores), one with all the affective responses, and one containing all the consumer background information. In regards to background information some of the variables were grouped into fewer categories to obtain larger segments (see Appendix 8). Regarding the question about chocolate consumption habits the category ‘white chocolate’ was omitted from the data set as no consumers had responded to this variable.

Univariate analyses
ANOVA was conducted in SPSS on the hedonic ratings and on the responses for the three collative variables. Consumer responses were considered as dependent variables and samples as fixed factor. Following post-hoc Tukey HSD test was performed to uncover the significant differences between the samples for each response variable. Differences were considered significant when p<0.05. Standard deviations for each variable were also calculated for each sample in Excel.

Multivariate analysis
Multivariate analysis was carried out in The Unscrambler X, version 10.3 (CAMO ASA, Norway). The data was imported to Unscrambler in three separate data matrices: X, Y and Z. Matrix X contained all the sensory data obtained from the CATA-questionnaires, matrix Y contained the affective responses and matrix Z contained the consumer background information which were turned into category data (1/0). The Y matrix was separated into four different matrices for the four response variables, respectively. The first data to be analysed included the sensory data only. An identity matrix was created for the products in order to display the samples in the model. The data was analysed by A-PLSR and D-PLSR using individual CATA-intensity scores. A-PLSR was performed to investigate if significant differences between the samples existed based on the consumers’ descriptive evaluation of the chocolates. D-PLSR was performed to uncover sensory descriptors responsible for the sensory differences. For both analyses, cross-validation was used with individual consumers as cross-validation segments. Martens’ Uncertainty test was used as part of the analysis to assess the significant sensory differences (Giacalone, Bredie & Frost, 2013).
Subsequently, the sensory data was reorganised so that non-significant descriptors were removed from the data set and individual CATA-intensity scores were transformed into mean values. In this way the X matrix had only six rows representing each of the samples and could thus be connected to the Y matrix. Prior to calculation of the models the variables were brought to a common origin by mean centring and because different scales were used for the data collection, standardization of the data was also necessary for some of the analyses (Martens *et al.*, 2005).

External Preference Mapping (PREFMAP) was conducted to find out how the sensory descriptors (X) were related to consumer liking (Y). PREFMAP is a PLSR model which is performed on both the X- and Y-matrices simultaneously. Thereby, it is possible to model the variables in X which will best predict the variables in Y. PLSR analyses were also performed for each of the three response variables: ordinary, novel, and high quality to investigate the correlations between these variables and the sensory attributes (Martens *et al.*, 2007).

A multiple linear regression (MLR) was performed on the affective data to investigate whether liking could be predicted from any of the collative properties. MLR is a type of ANOVA method that combines a set of X-variables in linear combinations and correlates these to one single response (Y) (Davis, 2011). In this case the X variables are the three collative variables and liking is the Y variable. In combination with this method, a PLSR analysis was performed in order to look further into the correlations between the collative properties and the individual liking responses.

The last analysis to be conducted was an L-PLSR which includes all three data matrices: X, Y and Z. The Z matrix is connected via the Y matrix and shares no matrix size dimensions with the X matrix. This method enables investigation of reliable patterns of variation in the liking data (Y) which can be explained from both sensory descriptors (X) and consumer background variables (Z). If such patterns do exist, it is possible to identify different consumer segments with different preference patterns and to uncover which product characteristics and consumer variables point to these variations (Martens *et al.*, 2005).
6.0 Results

In this section the results from the sensory study are presented. The first paragraph presents the results obtained from the specialist workshop. This section presents the vocabulary of sensory descriptors which were chosen for the descriptive analysis. A detailed analysis of the rapid profiling data is not included in the report but can be found in Appendix 9. The second paragraph presents the results from the consumer study and includes results from the univariate and multivariate data analysis.

6.1 Specialist Workshop

The analysis of the rapid profiling data was used to find important sensory descriptors of dark chocolate and to validate the choice of samples for the consumer test. It was considered important to include samples that were perceived as relatively dissimilar so that it was possible for the consumers to distinguish between the samples. Thereby the chance of investigating correlations between consumer liking and specific sensory characteristics of dark chocolate would increase. The results showed that Green & Black’s and Cadbury were perceived as very different from each other and also very different from both Bahen Madagascar and Bahen Brazil in both flavour and mouthfeel characteristics which thus validated the choice of samples.

Based on qualitative and quantitative analysis the final vocabulary was chosen. The descriptors fruity and creamy were omitted, and since off-flavours caused by poor fermentation or drying practices could potentially be a problem in the cocoa from PNG and Solomon Islands it was decided to include the attribute smoky as an additional descriptor. Smoky was in fact mentioned for some of the samples in the Napping exercise but as the descriptor was only used by one of the panelists it was initially omitted from the analysis. The final vocabulary thus consisted of 24 descriptors comprising of 18 flavour attributes and 6 mouthfeel attributes which are listed in Table 7 below.

Table 7: Overview of the final vocabulary

<table>
<thead>
<tr>
<th>Flavour descriptors</th>
<th>Mouthfeel descriptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raisin</td>
<td>Buttery</td>
</tr>
<tr>
<td>Red fruit</td>
<td>Floral</td>
</tr>
<tr>
<td>Yellow stone fruit</td>
<td>Nutty</td>
</tr>
<tr>
<td>Acidic</td>
<td>Honey</td>
</tr>
<tr>
<td>Roasted</td>
<td>Sweet</td>
</tr>
<tr>
<td>Bitter</td>
<td>Mouldy</td>
</tr>
<tr>
<td>Spicy</td>
<td>Earthy</td>
</tr>
<tr>
<td>Tobacco</td>
<td>Cocoa</td>
</tr>
<tr>
<td>Caramel</td>
<td>Smoky</td>
</tr>
</tbody>
</table>
6.2 Consumer Study

6.2.1 Univariate analysis

Mean scores and standard deviations for the response variables liking, ordinary, novel, and high quality are shown in Table 8 below for each of the six samples.

Table 8: Mean scores and standard deviations (SD) for the response variables liking, ordinary, novel, and high quality. The samples are listed in descending order according to mean liking values. Different letters behind SD indicate that the samples are significantly different in the corresponding variable (Tukey p<0.05).

<table>
<thead>
<tr>
<th>Samples</th>
<th>Liking</th>
<th>Ordinary</th>
<th>Novel</th>
<th>High quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green &amp; Black’s</td>
<td>6.74 ± 1.48c</td>
<td>3.14 ± 1.03b</td>
<td>2.65 ± 1.07a</td>
<td>3.28 ± 1.03b</td>
</tr>
<tr>
<td>Cadbury</td>
<td>5.85 ± 2.10b</td>
<td>3.56 ± 1.19b</td>
<td>2.77 ± 1.20ab</td>
<td>2.75 ± 1.15a</td>
</tr>
<tr>
<td>PNG</td>
<td>5.33 ± 1.83ab</td>
<td>2.83 ± 1.05a</td>
<td>3.24 ± 1.04bc</td>
<td>3.32 ± 0.92b</td>
</tr>
<tr>
<td>Madagascar</td>
<td>5.18 ± 1.76ab</td>
<td>3.27 ± 1.00ab</td>
<td>3.03 ± 1.09bc</td>
<td>3.00 ± 1.03ab</td>
</tr>
<tr>
<td>Brazil</td>
<td>5.06 ± 1.97a</td>
<td>3.01 ± 1.03a</td>
<td>3.20 ± 1.11bc</td>
<td>3.02 ± 1.06ab</td>
</tr>
<tr>
<td>Solomon</td>
<td>5.03 ± 1.79a</td>
<td>3.03 ± 1.06a</td>
<td>3.27 ± 1.08c</td>
<td>2.93 ± 1.00ab</td>
</tr>
</tbody>
</table>

Liking

As seen in Table 8, the average liking scores ranged from 5.03 - 6.74 among the six samples. Green & Black’s got the highest mean score of 6.74 and was thus generally the most liked chocolate followed by Cadbury with a mean score of 5.85. The Solomon chocolate got the lowest mean score of 5.03 and was thus generally the least liked. The post hoc Tukey’s test showed that Green & Black’s was liked significantly more than all the other samples (see significance letters in Table 8). Cadbury was liked significantly more than the Brazil and Solomon chocolates but not significantly more than PNG and Madagascar. No significant difference in liking was seen between the four samples from Bahen & Co. i.e. Madagascar, PNG, Brazil, and Solomon.

The range in mean liking scores is relatively narrow considering that the samples were evaluated on a 9-point scale. This means that even though there was a significant difference in liking between the samples, the difference was generally not very large. Furthermore, all samples got a mean score above 5 which shows that on average all the chocolate samples were liked by the consumers. However, the standard deviations range from 1.48 to 2.10 which show that the liking scores were spread out over a large range of values on the scale for all samples. This indicates that different and various preferences existed among the consumers. This is also supported by results from Internal Preference Mapping (not included in this report) which revealed a large span in liking across the consumers.
**Ordinary**

The Cadbury chocolate was evaluated as the most ordinary out of the six samples with a mean score of 3.56 on the 5 point Likert scale followed by Madagascar with a mean score of 3.27. The least ordinary sample was the PNG chocolate with a mean score of 2.83. Cadbury showed to be significantly different in this response variable from only the PNG, Brazil, and Solomon chocolates. Green & Black’s and Madagascar were not perceived as significantly different from any of the other samples in regards to the property ‘ordinary’.

**Novel**

The Solomon sample was perceived as the most novel chocolate followed closely by PNG with mean scores of 3.27 and 3.24 respectively on the 5-point scale. The least novel sample was Green & Blacks with a mean score of 2.65 followed by Cadbury with a mean score of 2.77. Solomon, Brazil, and PNG were perceived as significantly different from Green & Black’s in regards to the property ‘novel’. A significant difference was also perceived between Cadbury and the Solomon chocolate whereas no significant difference was found between the four samples from Bahen & Co. The findings reveal that the most novel sample is also the least liked chocolate whereas the least novel sample is the most liked chocolate.

**High quality**

The PNG chocolate had the highest mean score of 3.32 for the property ‘high quality’ followed by Green & Black’s with an average score of 3.28 on the 5 point scale. Cadbury was perceived as significantly different from PNG and Green & Black’s for this variable with the lowest mean score of 2.75 meaning that this sample was perceived as the lowest quality of the six samples. No significant differences were found among the other samples.

In general the standard deviations are relatively high for the affective variables which indicate large spreads in the data. However, since preferences are highly subjective and collative properties relate to the consumer’s prior experiences and associations this is not unexpected. In order to get insight into the sensory characteristics responsible for consumers’ preferences and responses multivariate data analyses was conducted.
6.2.2 Multivariate analysis

A-PLSR
The first data to be analysed by multivariate statistics dealt with the sensory data only. A-PLSR (not included in this report) was carried out to find out if significant differences between the six samples existed. The analysis was based on the consumers' evaluations of the chocolate samples and thus included the data from the CATA-questionnaires. The X matrix was an identity matrix created for the samples, and the Y matrix contained the sensory data. Two components were retained in the model (X explained variance: 40%, Y: 5%). The low explained variance in matrix Y can be explained by the fact that the model was calculated using individual CATA-intensity scores instead of mean values. However, a relatively low explained variance is generally not unexpected for this type of data.

The model showed that the samples generally were perceived as different from each other, especially Cadbury, Green & Black’s, and PNG. Results from the analysis also revealed that five of the six samples were significantly different in sensory characteristics (p<0.05). Only the Madagascar chocolate was not perceived as significantly different from the mean. Solomon and Brazil were perceived as very different from most of the other samples but not very different from each other which explain why these two samples got nearly similar mean liking scores. The A-PLSR bi-plot also showed that the four samples from Bahen & Co. were placed in the right part of the plot while Green & Black’s and Cadbury were both placed very far to the left. This shows that even though most of the samples were significantly different from each other in sensory characteristics the consumers perceived a pronounced difference between the premium and the mass-produced chocolates.

D-PLSR
To reveal the specific sensory descriptors responsible for the perceived differences between the samples, D-PLSR was performed. This model was obtained by interchanging the two matrices of the first model (X = sensory descriptors, Y = identity matrix for the samples. The model explains 22% of the variance in the X data and 9% in the Y data.
Figure 6 shows the correlation loadings for the sensory descriptors and the samples. As seen in the plot nearly all of the samples and descriptors are placed within the inner ellipse explaining less than 50% of the variance. This means that the patterns seen in the model are far from conclusive. The model also shows that only 14 of the 24 descriptors varied significantly (p<0.05) between the samples which explains the low explained variance in the model. Since the validity of the patterns shown for all the non-significant descriptors is very low, only the correlations seen for the significant descriptors can be considered valid in the interpretation of the model.

Descriptors and samples close to each other demonstrate a positive correlation. Hence, the descriptors sweet, buttery, caramel, and nutty are mainly describing the Cadbury chocolate. Green & Black’s seems to share some of the same characteristics however the two samples are differentiated in that Green & Black’s is correlated to the descriptors smooth, soft and yellow stone fruit although only smooth is significant. The descriptors red fruit and raisin which are placed in the lower right part of the plot are mainly correlated with the PNG chocolate although none of these attributes are significant. Spicy and acidic on the other hand are both significant descriptors which seem to have highest correlations with the PNG chocolate. Bitter seems to be describing for both the PNG and the Brazil samples and is the only descriptor placed in the outer ellipse and therefore has the highest explained variance.
Furthermore, bitter is placed opposite from sweet meaning that these two descriptors are negatively correlated. The Brazil chocolate is also correlated to the attributes drying, tobacco, mouldy, roasted, earthy, and smoky which are also describing the Solomon sample. The Madagascar chocolate is placed in the middle of the plot and thus shares sensory characteristics with most of the other samples which explains why this sample was not perceived as significantly different from any of the other samples.

In order to reduce some of the noise in the data, the model was recalculated via Martens’ Uncertainty test in which all the non-significant descriptors were omitted. Reinterpretation of the model was very consistent with the first findings in regards to the correlation patterns.

**External Preference Mapping**

In order to investigate how the sensory data was related to hedonic liking a PREFMAP was conducted with the sensory descriptors as X matrix and the liking responses as Y matrix. The model below shows the correlation loadings for external preference mapping and thus illustrates how consumer liking is related to the significant sensory descriptors. The model is explaining 96% of the variance in the X matrix and 55% of the variance in the Y matrix.

![PREFMAP on sensory descriptors (X) and consumer liking (Y). Correlation loadings plot showing principle component 1 and 2. The inner and outer ellipses represent 50% and 100% of explained variance, respectively.](image_url)
The red dots and numbers in the plot are representing each of the 88 consumers. The model shows that the consumers are spread out on the plot, yet most of them are placed in the mid right part of the plot nearest to the descriptors sweet, buttery, caramel, and nutty which means that these sensory characteristics are correlated to liking among most of the consumers. As seen in the plot Mean Liking is also placed around these descriptors. There is also a group of consumers who seem to cluster in the upper middle part of the plot which indicates that they have highest preference for acidic and smooth characteristics. Only a few consumers are placed near the descriptors bitter, tobacco, mouldy, earthy, smoky, and roasted on the left side which indicate that these sensory characteristics are preferred by only few of the consumers. The consumers placed close to the middle within the inner circle are not very well explained by the model.

Figure 8 below is a model of the weighted regression coefficients summarizing the relationship between all the significant sensory descriptors and the mean liking responses. The figure illustrates the importance of each descriptor for consumer liking. Descriptors with a large regression coefficient play an important role in the model which is illustrated by the size of the blue bars. A positive coefficient shows a positive link with the liking response, and a negative coefficient shows a negative link. Descriptors with a small coefficient are negligible.

![Figure 8: Weighted regression coefficients for mean liking based on results from Factor 1. The bars below the horizontal line illustrate a negative correlation between the descriptor and the response variable while bars above the horizontal line depict a positive correlation.](image)

The model shows that bitter and drying have the highest negative correlation with liking whereas sweet and buttery are the two predictors which are most important for liking of the chocolates. The other sensory characteristics also show either positive or negative links but these seem to play a smaller role in prediction of liking. However, predictors of liking differ from consumer to consumer which is also shown by the PREFMAP, Figure 7. The plot shows that there are many liking values placed far away from Mean Liking. Therefore it is not of very great value to look at average liking. From a marketing perspective it is more relevant to look at consumer segments and their related preferences. This provides argumentation for conducting the L-PLSR analysis in which various consumer background variables are included.
Prior to the L-PLSR analysis however, it was investigated how the sensory descriptors were correlated to the three collative properties. Three separate PLSR analyses were therefore carried out using the sensory data as predictor matrix (X) and the respective variable as Y matrix.

**Ordinary**

Results from the PLSR on the variable ‘ordinary’ (two components retained, X explained variance: 93%, Y: 50%) revealed that the perception of an ordinary chocolate varied a lot among the consumers which is shown in Figure 9 below. Many of the consumers are placed within the inner ellipse explaining less than 50% of the variance. However, a large part of the consumers are placed near the descriptors nutty, caramel, buttery, and sweet showing that these attributes were associated with an ordinary chocolate by many of the consumers. These descriptors were mainly characterising the Cadbury chocolate which was also evaluated as the most ordinary of the six samples.

![Figure 9: PLSR on sensory data (X) and responses to the variable ‘ordinary’ (Y). Correlation loadings plot showing the first and second principle component (PC). The inner and outer ellipses represent 50% and 100% of explained variance, respectively.](image-url)
**Novel**

Results from the PLSR on the variable ‘novel’ (two components retained, X explained variance: 93%, Y: 45%) showed that for this variable the consumers seemed to be more in consensus. Although a large part was placed within the inner circle explaining less than 50% of the variance the main part of the consumers were placed in the right side of the plot closest to the descriptors which were characterising the premium chocolates. These samples also got the highest mean scores for ‘novel’. Figure 10 below shows the importance of each descriptor for the perception of novelty.

![Figure 10](image)

Figure 10: Weighted regression coefficients for ‘novel’. The figure is based on the mean values and shows the results from Factor 1. The bars below the horizontal line illustrate a negative correlation between the descriptor and the perception of ‘novel’ while bars above the horizontal line depict a positive correlation.

Figure 10 shows that buttery, caramel, nutty, sweet and smooth have negative correlations with novel whereas all of the other descriptors show a strong positive correlation, especially bitter, drying and tobacco which explains why the premium samples were rated as more novel than the mass-produced chocolates.

**High quality**

Results from the PLSR on the variable ‘high quality’ (two components retained, X explained variance: 93%, Y: 45%) showed that also for this variable the consumers were very scattered in the correlation loadings plot (not included in the report). Most of them were placed within the inner circle although most of them were placed in the upper half of the plot with one cluster of consumers placed nearest the attribute acidic and another cluster nearest the descriptor smooth which explains why the PNG and Green & Black’s got the highest mean scores for high quality. The weighted regression coefficients for this variable (not included in the report) showed that earthy, smoky, buttery, caramel, mouldy, nutty, roasted and sweet had the highest negative correlations with high quality whereas bitter, acidic, spicy and smooth were most important for the perception of high quality. These correlations were explained by mainly Factor 2, 3 and 4.
Multiple Linear Regressions

It has been investigated which sensory characteristics of chocolate that are important for consumer liking and furthermore knowledge has been gained in regards to which attributes that are influencing consumers’ perception of the collative properties ordinary, novel, and high quality when it comes to dark chocolate. Results from the univariate analysis indicated that novelty is negatively correlated with liking. This gives reason to look more into the relationship between the response variables and find out if liking can be predicted from any of the collative properties. A multiple linear regression was therefore performed with liking as the dependent variable and the collative properties as independent variables. Table 9 shows the correlations between liking and each of the collative properties.

Table 9: Correlations between liking and the three collative properties shown by p-values and B-coefficients.

<table>
<thead>
<tr>
<th>Variables</th>
<th>p-value</th>
<th>B-coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinary</td>
<td>0.2258</td>
<td>0.0938</td>
</tr>
<tr>
<td>Novel</td>
<td>0.0000</td>
<td>-0.4699</td>
</tr>
<tr>
<td>High quality</td>
<td>0.0000</td>
<td>0.9202</td>
</tr>
</tbody>
</table>

The p-values in Table 9 reveal that ordinary is not predictive for liking (p<0.05) whereas novelty and high quality are both significant predictors of liking. The B-coefficient depicts the relative impact of the X-variable and whether the correlation is positive or negative. The table shows that novelty is negatively correlated with liking (-0.4699) while high quality is positively correlated with liking (0.9202). These results are supporting the findings from the univariate analysis which indicated a negative correlation between liking and novelty. Considering the positive correlation between liking and high quality it is interesting that the Cadbury chocolate was rated as lowest quality but at the same time was the second most liked sample.

PLSR analysis was carried out to look further into the correlations between the collative properties and the individual liking responses and in this way reveal the individual differences in the correlations. Mean scores for ordinary, novel, and high quality were used as X matrix and the individual liking responses as Y matrix. The model in Figure 11 explains 99% of the variance in the X matrix and 50% of the variance in the Y matrix.
The model reveals that high quality is only positively correlated with liking for a group of the consumers. Another large part of the consumers are placed in the upper right part of the plot opposite from the variable novel. This illustrates that novelty is negatively correlated with liking for these consumers which explains the results from the multiple linear regression. Ordinary seems to be negatively correlated with liking for some consumers and positively correlated with liking for other consumers which explains why this variable is not significantly predictive for liking. These results support the argumentation for conducting the forthcoming L-PLSR analysis in which underlying patterns of liking will be analysed.
L-PLSR

L-PLSR was performed in order to study potential consumer segments and their related preferences. This analysis was carried out by including a third data matrix \((Z)\) in the analysis i.e. consumer background variables.

Figure 12 below is a correlation loadings plot illustrating the relationship between the three data matrices \((X\text{ explained variance}: 96\%, Z: 24\%, Y: 9\%)\). The reason for the much higher explained variance in the \(X\) matrix is the smaller number of variables in the sensory data compared to the other matrices and also due to the fact that only significant descriptors are included in the model. This also explains why most of the sensory descriptors are placed near the outer ellipse.

The red dots and numbers in the plot illustrate the individual liking responses from the participants and indicate that various segments are found amongst the consumers. Mean scores for the three collative properties have been included in the \(X\) matrix and are thus shown in the model with a blue colour.
In regards to consumer background variables gender, age, income, chocolate consumption habits (milk/dark), and food interest seem to be most important for differences in liking of the chocolate samples. Factor 1 for instance distinguishes clearly between young consumers (18-25) and adults (26-45) + seniors (46-65) while Factor 2 distinguishes between female and male consumers. Quality and price also seem to be negatively correlated which is not unexpected. However, many of the background variables are placed close to the centre of the plot and are therefore not well explained by the model. The L-PLSR plot does not necessarily explain the importance of each of the variables for liking but rather the variables that differentiates the various segments. For instance, based on the L-PLSR plot taste does not seem more important for chocolate purchase than quality, price and cocoa percentage but when looking into the raw data the results reveal that taste was evaluated as most important for nearly 66% of the consumers. The small explained variance of this variable is explained by the fact that consumers across all the segments rated taste as most important. Other factors mentioned as most important for chocolate purchase were brand, interesting flavours and novelty, package size, and mood.

Based on visual interpretation of the model four different consumer segments can be described. One segment, placed in the upper left part of the plot, is predominantly females with medium interest in high quality food products. For this segment price seems to be the most important factor for chocolate purchase. These consumers have a preference for sweet and buttery characteristics and prefer the Cadbury chocolate over the other samples. A smaller group of consumers is placed around the Green & Black’s chocolate and like the smooth characteristic of this sample. These consumers are mainly young individuals with low income who most often consume milk chocolate. It is surprising that this group is not bigger since Green & Black’s was liked significantly more than the other chocolates. However, the explanation might be that the consumers who preferred this chocolate gave very high liking scores for this sample compared to the other samples or be due to the low explained variance in the Y matrix.

Another fairly big segment is seen in the lower right part of the plot. This segment is dominated by male consumers with high interest in high quality food products and for whom quality is the most important factor in regards to chocolate purchase. These consumers prefer the PNG chocolate with acidic, spicy and bitter characteristics. Another smaller group is depicted in the upper right part of the plot and these consumers prefer the Solomon and Brazil chocolates and thus characteristics such as bitter, roasted, earthy and drying. These are predominantly adults and seniors with medium income who most often consume dark chocolate.
From a more overall interpretation of the model there is a tendency showing that younger consumers prefer the mass-produced chocolates while the older consumers generally have a higher preference for the chocolates from Bahen & Co. The difference in liking of these chocolates also seems to be related to the type of chocolate (milk/dark) that is most often consumed and also the frequency of dark chocolate consumption. Consumers who most often consume milk chocolate generally have a higher preference for Green & Black’s and Cadbury which is not surprising as these samples are evaluated as sweeter and less bitter than the chocolates from Bahen & Co. and are thus closer to the typical characteristics of milk chocolate. Consumers with a high consumption of dark chocolate also have a higher preference for the premium chocolates than consumers with lower consumption frequencies (less than once a week). Furthermore, males seem to have a more pronounced preference for acidic flavour notes compared to their female counterparts.

The various consumer segments described above are some overall tendencies which can be depicted from the L-PLSR model and should only be considered as potential segments. Due to the relative small amount of participants in the study it is not possible to draw conclusive interpretations about consumer segments from this analysis.


7.0 Discussion

When interpreting results from a sensory study, it is important to keep in mind that the outcome may have been affected by several factors, especially since human subjects are involved. Different issues influencing the results of this study are discussed in this section.

CATA-method

Before choosing a method for a sensory test various factors must be considered including aim of the study, financial costs, time, and human resources. In this study time and financial resources have been limited and therefore it was necessary to find a valid method that was relatively quick and low cost. This explains the choice of using consumers for both the affective and the descriptive test and conducting the two tests within the same session. However, both of these choices may have influenced the outcome of the study. According to the traditional view on sensory evaluation consumers should only be used for affective tests. Since consumers are untrained assessors they may not have the same discriminative ability as trained panellists and are thus not optimal assessors for analytical descriptive tests. Especially when product differences are small it may be difficult for consumers to discriminate between the products. Furthermore, lack of training may result in misunderstanding of the attributes. However, several studies have shown that descriptive profiles given by consumers are both discriminative and repeatable and similar to those given by trained panellists which prove the validity of using consumers for descriptive tests. Companies are therefore increasingly using untrained consumers for analytical tests to save time and money and to enhance external validity (Giacalone, Bredie & Frøst 2013; Moskowitz, 1996). The concern about combining the two tests in the same session is based on the possibility that the attribute consideration may have influenced the hedonic response and vice versa. The results may thus have been different if the tests had been carried out in different sessions (Meilgaard et al. 2007).

The choice of using the CATA-method for this study was based on the fact that this method is much simpler and less time consuming than conventional descriptive methods. This is also why the method is increasingly preferred over traditional descriptive methods (Bruzzone, Ares & Giménez, 2012). Sensory profiles obtained from consumers via the CATA-method have shown to be similar to sensory profiles obtained from trained panellists via conventional methods which prove the validity of the method. Most of these results however are based on the traditional CATA-method which does not include intensity scales. The effect of combining the CATA-method with intensity scales was studied by Reinbach et al. (2013) but the results showed no significant advantages or disadvantages of the scales compared to the traditional CATA-method. However, this study was conducted on products with relatively large sensory differences which may reduce the relevance of
intensity scales (Reinbach et al., 2013). In this study however the differences between the samples were hypothesized to be relatively small and intensity scales were therefore considered to enhance discrimination between the samples. Nevertheless, it is important to take into account that due to lack of training, inconsistency in the use of scale will produce a lot of noise in the data. The application of intensity scales in this study thus has the disadvantage of a large variability in the consumers’ descriptive evaluations which reduce the validity of the results and may explain the many non-significant attributes. Another drawback of the method is that evaluation of the samples is restricted to a predefined list of attributes which limits the differentiation of the samples to these descriptors. Some variance may therefore be missed. Although the CATA-method is a good way to get insight into how different sensory characteristics influence consumers’ preference patterns it must be kept in mind that descriptive profiles obtained by this method may not be highly accurate (Giacalone, Bredie & Frøst, 2013; Reinbach et al., 2013).

Despite the weakness of the CATA-method, significant differences in sensory profiles were found for five of the six samples. Hence, this study supports previous research showing that untrained consumers are capable of discriminating between products in descriptive analyses. The samples were differentiated by various flavour and mouthfeel attributes but in particular by taste descriptors (bitter, sweet and acidic) which was also seen in the study by Thamke, Dürrschmid & Rohma (2009) mentioned in paragraph 1.4. This indicates that taste attributes may be easier to assess than flavour attributes for untrained consumers. Nevertheless, the results support the author’s expectations and the literature on several counts which prove the potential of the method.

The Brazil chocolate for instance was correlated to the descriptors bitter and drying (astringent) which are characteristic for fine flavour cocoa from the Bahia region, cf. paragraph 3.2.3. The evaluation of the PNG chocolate was also consistent with other studies showing that cocoa from PNG is characterized as spicy and very acidic compared to other regions, cf. paragraph 3.2.3. Furthermore, the Cadbury sample was positively correlated to nutty and negatively correlated to acidic which are consistent with the fact that the company uses cocoa beans from West Africa (Ghana) which are known to have nutty tones and low levels of acidity, cf. paragraph 3.2.3. Moreover, the consumers generally evaluated the two mass-produced chocolates, Green & Black’s and Cadbury, to be very different from the four premium chocolates which could be expected due to differences in ingredients and production method. The sweeter and less bitter flavour notes of the mass-produced samples are probably caused by the additional ingredients in these chocolates such as milk powder and flavours. The findings showing that the Solomon and Brazil samples were positively correlated to the attributes mouldy, smoky and tobacco indicate presence of off-flavours in the cocoa beans which may be caused by poor farming practices cf. paragraph 3.3.
Attributes
Since the descriptive profiles were restricted to a predefined list of attributes the choice of attributes is obviously essential for the outcome of the study. In this study the attributes were obtained from a group of chocolate specialists by use of a rapid profiling method. The advantage of this method was that relevant descriptors of both premium and mass-produced dark chocolates could be obtained. However, since the panellists were experts and used to recognizing various chocolate flavour and mouthfeel characteristics there is a risk that some of the attributes may have been difficult for naive consumers to understand or perceive. Furthermore, the analysis of the Napping data showed that the panellists used a lot of different descriptive terms for the samples which made the analysis and the choice of vocabulary difficult and may have resulted in some missing relevant descriptors. However, it was considered important not to include too many attributes in the study and therefore it was necessary to omit some descriptors by only including words mentioned by at least two panellists and to group the descriptors into categories. Thereby, it is likely that some variation may have been missed. Furthermore, the PNG and the Solomon chocolates were not included in the Napping exercise as these samples were not yet produced at the time of the specialist workshop. Hence, there is a possibility that attributes related to these two samples were not included in the CATA-questionnaire.

Consumer responses
Results from the hedonic test showed that the mean liking scores for the six samples ranged from 5.03 - 6.74 on the 9-point scale. This relatively narrow range can be explained by the fact that the scale was bimodal and thus had a neutral category in the middle which left only a few choices of positive responses. Nevertheless, liking varied significantly among the samples. Green & Black’s for instance was liked significantly more than the other chocolates and Cadbury was liked significantly more than Brazil and Solomon. The PNG sample was generally the most liked among the four premium chocolates followed closely by Madagascar. This indicates that the PNG cocoa has a good potential of success on the premium chocolate market considering that Madagascar and Brazil are already sold on this market. The Solomon chocolate on the other hand got the lowest mean liking score and was correlated to off-flavours which question the potential of this chocolate. However, this sample was generally perceived as very similar to the Brazil chocolate both in sensory characteristics and in liking. Although these results indicate that the PNG cocoa may have better potential than the Solomon cocoa it must be kept in mind that the difference in liking between the premium samples was not significant and moreover that the results are based on average scores. Furthermore, all the samples got a mean liking score above 5 which means that on average they were all liked.
Based on the psychological theories described under section 4.2, perceptions of collative properties were investigated in the consumer test in order to uncover the influence of these on hedonic liking. Results from the data analysis showed that novelty and high quality were predictive for liking with a negative and a positive correlation, respectively. The Solomon and the PNG chocolates were evaluated as the most novel samples which could be expected as these two samples are not available on the market. The Solomon sample also got one of the lowest mean scores for high quality. Since both novelty and high quality were predictive in opposite ways, this may explain why the Solomon sample got the lowest average liking score. However, it may also be related to the fact that this sample was positively correlated to some off-flavours. Cadbury which was the second most liked sample was also perceived as the most ordinary and the second least novel sample. This was also expected as this chocolate is a relatively cheap mass-produced chocolate which is broadly distributed in Australia. Green & Black’s, which was the most liked sample, was also perceived as the least novel sample. These findings indicate that the consumers generally prefer a chocolate that is familiar and point to the hypothesis that liking increases as the perception of novelty decreases which support the arousal theories, cf. paragraph 4.2. In this case it is not surprising that Green & Black’s and Cadbury were both generally preferred over the premium chocolates. Since the mass-produced chocolates are available in most large supermarkets in Australia there is a great possibility that at least one of these chocolates was familiar to the consumers in this study. Contrarily, the samples from Bahen & Co. were expected to be perceived as novel to most of the consumers since two of them are not on the market and the two others have limited availability.

Since these results are based on average scores it does not mean that the consumers agreed in their responses. The consumers had different perceptions of the collative properties and the multivariate analysis also revealed different consumer segments related to liking of the six samples. This means that although most of the consumers preferred the mass-produced chocolates there was also a large group of consumers who preferred the premium and more novel samples. This may be explained by individual differences in optimal arousal level cf. Berlyne’s arousal theory, paragraph 4.2.3. The L-PLSR plot showed that the consumers who generally preferred the premium chocolates were predominantly consumers above the age of 26 whom most often consumed dark chocolate and for whom quality was most important when buying chocolate. The mass-produced chocolates may have been perceived as too simple and familiar to these consumers. Bahen & Co’s chocolates on the other hand being more novel may have had a more optimal arousal potential for these consumers. However, as mentioned under paragraph 6.2.2 (L-PLSR) the small amount of participants must be considered in the interpretation of consumer segment. A larger sample of consumers would have increased validation of the segments.
**Consumers**
The choice of consumers is also important for the outcome of the study. For some consumers price for instance plays a more important role than for others, especially in regards to products such as premium chocolates which are normally consumed as a luxury treat rather than a basic food product. This study showed that price seemed to be most important for chocolate purchase for the consumers with low incomes whereas quality was most important for consumers with higher incomes, although these variables were only rated as most important by 12 and 19 consumers, respectively. Taste was chosen as most important by the majority of the consumers in this study. However, it is logical to assume that consumers with higher incomes generally have a higher consumption and preference for premium chocolates compared to consumers with low incomes which was also the pattern seen in this study. Since the consumers were predominantly individuals with low incomes (68%) and many of them most often consumed milk chocolate it can be discussed if this consumer group was suitable for a study on premium dark chocolate. The results may have turned out differently had the study predominantly included consumers with high incomes who were frequent consumers of premium dark chocolates. In this case, the chocolates from Bahen & Co. would possibly have received higher average liking values and have been preferred over the mass-produced chocolates by most of the consumers. The recruitment of consumers for this study however was limited by practical circumstances and it was therefore not possible to recruit enough participants if the screening criteria had been more restricted. Nevertheless, the results provide important information about the relative sensory appeal of the chocolates.

**Context**
Another imperative aspect to discuss in regards to the results of this study is the context in which the chocolates were tested. As described earlier in the report preferences and the way people perceive food is highly influenced by the context and the surrounding environment. The choice of setting and location in this study was based on practical and financial as well as methodological considerations and it can be discussed to which extend this may have influenced the results. It was not possible to conduct the five test sessions in the same venue and neither at the same time of the day. Differences in these contexts may thus have affected the perceptions of the samples resulting in different evaluations. In regards to time of the day, consumption of chocolate at 10am may not have been perceived as appropriate and the relatively early test sessions may thus have resulted in lower hedonic ratings than if all the sessions had been conducted later during the day. The choice of using a laboratory setting for the test was based on the view that a quiet and controlled atmosphere was important, especially in regards to evaluation of the descriptive profiles.
In regards to hedonic liking and collative perceptions however, the possible influence of this kind of setting must be considered. In natural settings, perceptions of the chocolates would be influenced by the context such as where, when and with whom the chocolate was consumed. For some consumers mass-produced chocolates might be consumed while watching a movie whereas premium chocolates may only be enjoyed on special occasions with good friends. For others chocolate may usually be consumed in combination with a beverage such as coffee or tea. Tasting chocolates in isolation in artificial settings is unusual for the consumers which may affect the perception of the samples and result in altered liking. Moreover, it is important to bear in mind that studying hedonic liking in isolation is not always a good predictor of consumer preferences and consumption in the real world. Food choice decisions involve many other influences than the simple sensory appeal of a product, cf. paragraph 4.2. Expectations and attitudes towards a product may be more important for consumption and food choice than the actual taste and hedonic liking. A product will thus not necessarily be successful on the market just because it receives high hedonic scores or because it is preferred over another product in a sensory test and vice versa (Lawless & Heymann, 2010).

**Exposure**

Considering the influences of mere exposure, single hedonic responses to a product may have very little predictive value for long term liking. Since the data of this study are based on only one hedonic test it would thus be interesting to test the effect of repeated exposure and find out if liking of Bahen & Co’s chocolates would increase if the test was conducted in several replicates on the same consumers. Based on Zajonc’s (1968) theory, mere exposure would increase liking of all the samples among all the consumers solely due to the repeated exposures. Based on the arousal theories however, repeated exposure to the samples could increase liking for some of the samples as novelty is reduced whereas liking could possibly decrease for the initially most liked samples due to product boredom or slowly rising aversion. According to these theories increased liking only applies to complex stimuli that are slightly above the consumer’s optimum arousal level. It is therefore possible that repeated exposures would increase liking of Bahen & Co’s chocolates for some of the consumers while liking of the two mass-produced chocolates would decrease for a large part of the consumers as they become too simple and familiar. However, perceived complexity has not been investigated in this study and it is therefore difficult to predict the effect of repeated exposure to these samples. Nevertheless, the theories indicate that the sample that is initially most liked is probably not the product with most potential on the market. A slightly less liked but more complex product will probably be appreciated for a longer time. Yet, it is essential that the product is liked to a certain extend at first exposure and not just over time in order to be re-purchased.
8.0 Conclusion
A descriptive analysis and consumer acceptance of six dark chocolate samples varying in quality, cocoa genetics and origin have been obtained, and correlations between liking and collative properties have been investigated. Moreover, underlying patterns of liking have been uncovered.

Results showed that five of the samples were evaluated significantly different in sensory characteristics. Only the Madagascar sample was not significantly different from the mean. The largest sensory differences were perceived between the mass-produced and the premium chocolates. The attributes smooth, sweet, nutty, caramel, and buttery were positively correlated to the mass-produced chocolates whereas the Solomon and Brazil chocolates in particular were positively correlated to drying, earthy, mouldy, smoky, tobacco, roasted and bitter characteristics. The PNG chocolate was described as predominantly acidic, spicy and also bitter.

On average the mass-produced chocolates were preferred over the premium chocolates and Green & Black’s was liked significantly more than the other samples. No significant differences in liking were seen among the premium chocolates. The collative properties 'high quality' and 'novel' were found to be predictive for liking with a positive and negative correlation, respectively. The premium chocolates were all perceived as more novel than the mass-produced chocolates which may explain why they were less preferred considering the psychological arousal theories. The multivariate analysis however revealed that different samples were preferred by different consumers and depicted a tendency of various consumer segments related to the differences in liking. An overall interpretation showed that the mass-produced chocolates were preferred by mainly young consumers with low incomes who most often consumed milk chocolate and had a medium interest in high quality food products. Preference for the premium chocolates was dominated by older consumers (26+) with higher incomes who had a high interest in high quality food products and most often consumed dark chocolate. For the majority of the consumers taste was rated as most important for chocolate purchase, but price and quality also seemed to distinguish the segments.

Based on the multivariate data analysis the results of this study indicate that South Pacific cocoa has excellent flavour potential for the premium chocolate market, yet it is important to consider consumer segments in marketing strategies. The PNG sample was generally perceived as highest quality of the six samples, and was also the most liked among the premium chocolates which favour the potential of the PNG cocoa. The Solomon Island cocoa may benefit from improved farming practices to get rid of off-flavours before it is used for production of premium chocolates.


8.1 Perspectives
When conducting a sensory study the aim is to obtain valuable information about a specific product and/or a specific consumer group which is beneficial to someone and can be used for instance in product development, marketing strategies or optimization of processes.

The results of this study are of relevance for chocolate manufacturers and provide background knowledge about consumers’ preferences in regards to dark chocolate. The findings emphasize the importance of considering the fact that consumers have very different preferences when a new chocolate is produced. By knowing which sensory characteristics of chocolate consumers in the target group prefer, there is a greater chance of product success.

The study also provides valuable information to the cocoa industry in regards to cocoa quality. The results are beneficial for particularly the parties involved in the cocoa projects in Papua New Guinea and the Solomon Islands. The sensory characteristics of the chocolates provide information about the presence of desired and undesired flavour compounds. This knowledge is relevant to the farmers as well as the manufacturers in that it may indicate if certain steps during the production can be optimized in order to avoid or provoke certain flavours. For instance the findings of this study showed that off-flavours were present in the Solomon Island cocoa which indicate that the cocoa beans may benefit from optimized farming practices.

Further research on the cocoa including DNA extractions and chemical analysis will provide more knowledge about the specific genetics and aroma compounds in the beans. Combined with the sensory evaluation of the chocolates it is possible to relate chemical data to the sensory attributes and thereby obtain meaningful knowledge to guide the chocolate and cocoa industry on the choice of future plantations of cocoa genetics.

Sourcing cocoa beans of a desired quality often requires that the chocolate manufacturer has direct contact with the farmers and knows how the beans have been handled during fermentation and drying. In the future it could be relevant for the cocoa and chocolate industry to find a consistent and easy method to identify cocoa quality in order to optimize trading and minimize economic losses. For instance it has been proved that it is possible for a trained panel to differentiate between cocoa liquors varying in cocoa quality (fine flavour and bulk cocoa), genetics and crop years by use of an optimized protocol for sensory assessment (Sukha & Butler, 2006).
9.0 References


Sensory evaluation and consumer acceptance of new premium dark chocolates


Personal references


10.0 List of Tables

Table 1: Global production of cocoa beans .................................................................................. 16

Table 2: Average composition of whole ripe cocoa beans .............................................................. 17

Table 3: Organic acid levels in cocoa beans from different geographic regions ....................... 18

Table 4: Overview of the samples used for the rapid profiling ....................................................... 37

Table 5: Groupings of the relevant flavour and mouthfeel descriptors ........................................ 40

Table 6: Overview of samples used for the consumer test ............................................................... 45

Table 7: Overview of the final vocabulary ..................................................................................... 51

Table 8: Mean scores and standard deviations for liking, ordinary, novel, and high quality ......... 52

Table 9: Correlations between liking and the three collative properties ..................................... 60
11.0 List of Figures

Figure 1: Influential and determining factors for chocolate flavour development........................................22

Figure 2: Conceptual model of affection-related chocolate choice (MARCC)..................................................29

Figure 3: The Wundt Curve by Berlyne.........................................................................................................32

Figure 4: Arousal theory by Dember and Earl.................................................................................................33

Figure 5: Illustration of the arousal theories of Berlyne, Dember and Earl, and Walker.................................34

Figure 6: D-PLSR on sensory descriptors and samples....................................................................................55

Figure 7: External Preference Mapping...........................................................................................................56

Figure 8: Weighted regression coefficients for liking.......................................................................................57

Figure 9: PLSR on sensory data and responses to ordinary.............................................................................58

Figure 10: Weighted regression coefficients for novel....................................................................................60

Figure 11: PLSR on the collative properties and consumer liking.................................................................61

Figure 12: L-PLSR........................................................................................................................................62
12.0 Appendices

Appendix 1: Macronutrient Composition of Cocoa Beans

Appendix 2: Affective test - Questionnaire

Appendix 3: CATA Questionnaire

Appendix 4: Participant Background Information

Appendix 5: Advertisement for Consumer Test

Appendix 6: Screening Questionnaire

Appendix 7: Test Instructions

Appendix 8: Groupings of Consumer Background Variables

Appendix 9: Data Analysis – Rapid Profiling