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Research Article

DETERMINING CONSUMER ACCEPTABILITY OF VEGAN CHOCOLATE IN TERMS OF GASTRONOMIC SUSTAINABILITY

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Abstract

Gastronomic approaches not only meet health expectations, but also lead to increased interest in vegan products in terms of sustainability. The fact that chocolate is enjoyed by a wide range of consumers leads to questioning the texture and taste acceptability of vegan chocolate formulations. The study was carried out to compare the preferabilities of vegan and standard chocolate samples in terms of texture and flavor profiles. Texture analysis, flavour profile analysis (LPA), and hedonic scale methods were employed to assess the preference and overall desirability of chocolates. The Statistical Package for the Social Sciences (22.0) was used to conduct correlation and ANOVA tests in order to statistically analyse the outcomes of tests conducted on a group of 30 panellists who received separate training and were then tasked with evaluating chocolates. It was determined that the negative correlation between the perception of softness and the perception of roughness, as perceived by trained panelists, strengthened the feeling of melting in the mouth, thus supporting the formation of the desired chocolate mouthfeel. Depending on the amount of cocoa butter, the mouthfeel perceived by melting was also felt quite clearly by non-vegan individuals. Based on this, it has been revealed that the flavors of vegan chocolate are similar to standard chocolates and that vegan chocolates can be preferred by non-vegan consumers. In all chocolate samples, the mouthfeel was largely affected by cocoa and oily taste. It reveals that textural melting and softness support the mouthfeel in non-vegan individuals, and that the perception of vegan chocolate was not different from the perception of standard chocolate in terms of these defined features.

Keywords: Vegan, Vegan Chocolate, Consumer Adoption Behavior, Flavor Profile Analysis, Texture Profile Analysis

Introduction

Some people choose not to eat animal products because they believe it is wrong, want to live a healthy life, care about animal rights, or care about the environment (de Koning et al., 2020; Estell et al., 2021; Safdar et al., 2022; Wang et al., 2022). Recent years have witnessed a notable surge in the adoption of vegan nutrition worldwide, with particular prominence in European, American, and Asian nations (Earle and Hodson, 2017). The rise in vegan nutrition has been attributed to multiple factors (Dedehayir et al., 2019). However, a closer examination of studies reveals a significant rise in the global adoption of vegan diets, with an increase of sevenfold in the number of individuals adhering to veganism. Furthermore, over the past three years, approximately 20% of food and beverage establishments have incorporated vegan products into their menus (Uçan Kayaalp et al., 2023). In addition, the nutritional preferences of women and generation Y have shifted in this direction (Alae-Carew et al., 2021). According to Kerschke-Risch (2014), the data obtained from publishing houses in 2011 indicates that the annual number of books produced on the subject of vegan diet was 11. The fact that this number rose to 2,779 by 2019 demonstrates the extent of veganism's popularity (Miguel et al., 2021). The emphasis on the importance of proceeding to more plant-based diets due to the relevance of sustainability, on the other hand, has influenced the speedier manufacture of vegan products (Aymankuy and Topal, 2022). The aforementioned circumstance also imposed an impact on the chocolate industry, leading to the emergence of many vegan chocolate products being introduced to the market.

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Chocolate remains indispensable for many people today, as it was in the past (Sexton, Garnett, and Lorimer, 2022), and chocolate consumption is increasing on a global scale day by day. The estimated average annual chocolate consumption per person in the globe is 0.9 kilogrammes (ProFound, 2022; Appenheimer et al., 2021). Despite chocolate being manufactured in alignment with contemporary dietary trends, it appears that cocoa has undergone diverse production methodologies from its initial discovery. The cocoa adventure, often referred to as the "food of the gods" (Wood, 2001; Moss and Badenoch, 2009; Lopes and Pires, 2015), initially began with its utilisation in the manufacturing of drinks. This journey continued to the European continent after the discovery of the American continent. The addition of sugar by the Spanish contributed to the widespread popularity of this beverage (Minifie, 1989; Beckett, 2000). Chocolate as we know it today was greatly influenced by Van Houten's creation of a mechanism that can separate cocoa butter from roasted cocoa beans (Samancı, 2012); The technique adopted by Joseph Fry in 1847 facilitated the initiation of the first modern chocolate production in England (Beckett, 1999; Beckett, 2000). Milk chocolate, an issue that has drawn attention since its inception, was first introduced in 1879 by Swiss chocolatier Daniel Peter, who incorporated the milk powder previously developed by chemist Henri Nestle into the chocolate production process (Gioffre, 2011). The advent of the velvety and smooth texture of chocolate can be attributed to the development of a machine by Rudolph Lindt, a Swiss innovator, in the year 1879. The utilisation of this machine facilitated the execution of the step known as "conching" in the process of chocolate production (Afoakwa, 2010). Therefore, the production of chocolate is categorised into two types of methods: the classical approach and the modern approach. The classical approach involves a series of procedures including mixing, grinding, conching, and packaging (Kaya and Şekeroğlu, 2012). On the other hand, the current approach encompasses five distinct stages: mixing, refining, conching, tempering, and shaping (Afoakwa, 2010).

While it is well known that chocolate, in particular, has a high volume and is widely produced in the current era, it can be found on the market in a variety of formulations to suit different preferences. Furthermore, the concept of upholding ecological integrity across all phases of manufacturing is steadily gaining significance. Similarly to the food business, chocolate production has essentially become a major issue, and developments in the field have caused a surge in product development. Nevertheless, it is pertinent to note that chocolate manufacturers who focus on sustainable food production and create vegan food innovations aim to appeal to a broader target audience, including non-vegan individuals (Appenheimer et al., 2021). Therefore, understanding consumers' taste perceptions of vegan products is of great importance in terms of understanding the factors affecting consumer preferences and ultimately determining the success of sustainable food production initiatives. Considering that vegan chocolates are predominantly preferred by people who adopt a vegan lifestyle, we believe that investigating the preferences of non-vegan individuals towards vegan chocolates will provide more effective results. The aim of this study is to examine the taste impressions of non-vegan people and evaluate them by comparing them with the perceptions of standard chocolate and vegan chocolate.

Materials and Methods

"Ethics Committee Approval" dated 22.06.2023 and numbered 2023/04 was received from Balıkesir University, Social and Human Sciences Ethics Commission for this study.

Chocolate samples

The chocolates and hazelnuts utilized in the production of chocolate and hazelnut chocolate samples were obtained from a supermarket chain. Chocolates with cocoa percentages of 53% and 54% were specifically chosen for the manufacturing of vegan and standard chocolates, respectively. Table 1 presents the nutritional values included in the label information of vegan and standard chocolates purchased from local markets.

Table 1. Composition of energy and nutritional elements in chocolate samples

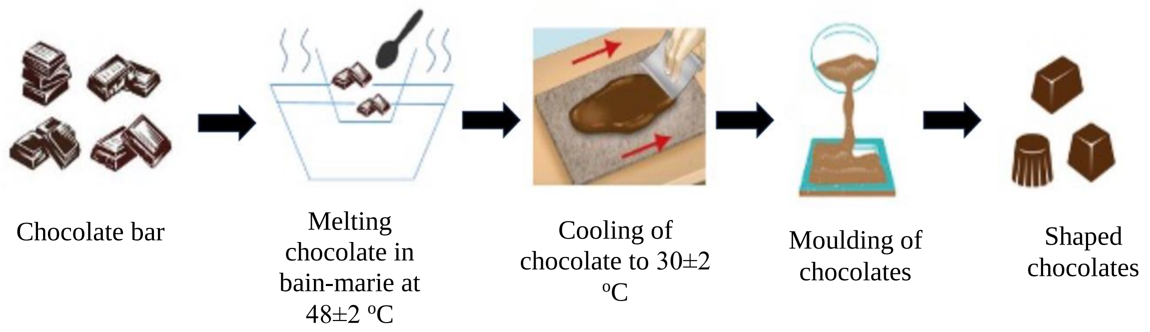
* Nutrition Information (Per. 100 gr)	Vegan Bitter Chocolate	Standard Bitter Chocolate
Energy (kcal)	538	540
Fat (gr)	34	34
Saturated fat (gr)	20	22
Carbohydrate (gr)	49	48
Sugars (gr)	46	45
Fiber (gr)	7.8	9.5
Protein (gr)	5.0	6.1

Salt (gr)	0.01	0.01

Preparation

During the sensorial analysis of vegan and standard chocolates, a portion size of 10 grams was determined. Additionally, 2 grams of hazelnuts were added to each variation of diversified vegan and standard bitter chocolates. To ensure standardized quality characteristics such as texture, appearance, and flavor during the panel evaluation, the chocolates underwent tempering process prior to shaping. This involved melting the chocolates over a hot water bath to reach a temperature range of 48±2 °C, followed by continuous stirring until the temperature dropped to 30±2 °C, for cooling. To mitigate the bias of assessors towards certain shaped chocolates and ensure uniformity, after the cooling process, chocolate samples were processed and poured into semi spherical molds (Figure 1). The chocolate samples were prepared for analyses into four groups named as standard bitter chocolate (SC), hazelnut standard bitter chocolate (SHC), vegan bitter chocolate (VC), and hazelnut vegan bitter chocolate (VHC).

Fig. 1. Preparation of chocolate samples for sensorial analyses.



Sensorial evaluation

Sensorial evaluation of four types of chocolates, namely standard chocolate (SC), standard hazelnut chocolate (SHC), vegan chocolate (VC), and vegan hazelnut chocolate (VHC), were conducted at the Kırklareli University Gastronomy and Culinary Arts Kitchen. "Ethics Committee Approval" dated 22.06.2023 and numbered 2023/04 was received from Balıkesir University, Social and Human Sciences Ethics Commission for this study.The sensorial properties of the chocolates were described using the sensorial profiling method outlined in ISO 13299 (2003), which involved two distinct phases integrating flavor profile analysis (FPA) and texture profile (TPA) panel.

a) First phase: Training and validation of assessors

During the training phase, assessors were carefully selected, trained, and validated to ensure their ability to simultaneously recognize and distinguish between the five basic tastes and their sensitivity to taste concentrations, as specified in ISO 3972 (2011) and Wang et al. (2020). The training program aimed to develop sensorial memory among the assessors by utilizing specific vocabulary and scales to effectively describe the texture of the formulated chocolates. The training comprised two parts:

Theoretical class: A comprehensive theoretical class on sensorial analyses and texture attributes was conducted to familiarize the selected members with texture concepts and the texture profile method.

Practical training: Assessors underwent practical training using solutions containing precise concentrations of various substances to assess their proficiency in detecting and identifying specific odors, as prescribed by ISO 5496 (2006). Ranking tests were performed using samples with different concentrations of sugar, salt, chili oil, monosodium glutamate, and citric acid to evaluate sensorial attributes in accordance with ISO 8587 (2006). Texture profile analysis utilized scales to assess softness, hardness, stickiness, chewability, granularity/particle size, and mouthfeel/melting in the mouth. FPA employed scales to evaluate sweetness, cocoa flavor, oily taste, bitter taste, aftertaste, and unpleasant taste.

b) Second phase: Evaluation of chocolate samples

Once the assessors were trained and validated, they proceeded with the sensorial analysis of the chocolates (SC, SHC, VC, and VHC), which were stored at 4±1°C. The evaluation encompassed FPA, texture profile analysis, and hedonic test techniques to determine the preferred option between standard and vegan chocolates. Each chocolate sample was evaluated individually by the assessors to determine its flavor profile. Specific sensorial analysis forms were utilized for each sample, incorporating a questionnaire that covered the texture and FPA characteristics of the chocolates. Panelists rated the expected flavor and texture attributes on a scale of 1 to 5, with 1 indicating no perception and 5 denoting a strong perception. The FPA and texture characteristics of the chocolates were determined based on previous studies (Viaene and Januszewska, 1999; Andrae-Nightingale et al., 2009; Lemarcq et al., 2022). To ensure an objective evaluation, the panelists remained unaware of any information regarding the samples.

Statistical analyses

The data collected in the conducted study, which aimed to compare the flavors and textures of vegan bitter chocolate, hazelnut vegan bitter chocolate, standard bitter chocolate and hazelnut standard bitter chocolate, were analysed using IBM SPSS Statistics (Version 22) software. This analysis involved conducting a one-way analysis of variance (ANOVA), a post hoc test (Tukey), and a correlation test to identify any significant differences between the samples.

Results and Discussion

Texture profile

The study determined the texture attributes to be utilised as softness, hardness, stickiness, chewiness, granularity/roughness, and melting in the mouth factors.

Table 2. Texture profile correlation of standard chocolate

Variables	Softness	Hardness	Stickiness	Chewability	Granularity/ roughness	Melting in the mouth
Softness	-					
Hardness	0.268	-				
Stickiness	-0.318	-0.015	-			
Chewability	0.214	-0.105	0.521**	-		
Granularity/Roughness	-0.292	-.0057	0.438	0.393	-	
Melting in the Mouth	0.352	0.056	0.414*	0.323	-0.082	-

: *p< .05* , **:*p< .01

Upon analysing the correlation analysis findings pertaining to the texture attributes of standard chocolate, a highly significant and positive correlation ($p<.01$) was observed between the parameters of chewability and stickiness. Furthermore, a statistically significant and positive correlation ($p<.05$) was observed between the parameters of melting in the mouth and stickiness, as presented in Table 2.

It has been observed that the perception of chocolate as being soft increases the rate of melting experienced in the mouth (Table 2). This situation leads to a decrease in the perception of granularity/roughness and chewability parameters in chocolate (Lemarcq et al., 2022).

Table 3. Texture profile correlation of vegan chocolates

Variables	Softness	Hardness	Stickiness	Chewability	Granularity/ roughness	Melting in the mouth
Softness	-					
Hardness	0.471	-				
Stickiness	0.398**	0.173	-			
Chewability	0.538**	0.314	0.228	-		
Granularity/roughness	0.356*	0.390	0.426	0.434	-	
Melting in the mouth	0.333	0.308	0.275	0.208	0.409	-

: *p< .05,* **:*p< .01

Based on the results derived from the correlation study conducted on the textural attributes of vegan chocolate, a highly significant and positive connection ($p<.01$) was observed between the softness and stickiness variables. Furthermore, a strong and statistically significant correlation ($p<.01$) was seen between the variables of softness and chewiness. On the other hand, it was found that there existed a statistically significant and positive correlation (p<.05) between the parameters of granularity/roughness and softness, as indicated in Table 3.

Table 4. Texture profile correlation of hazelnut standard chocolates

Variables	Softness	Hardness	Stickiness	Chewability	Granularity/ roughness	Melting in the mouth
Softness	-					
Hardness	0.369	-				
Stickiness	0.055	0.143	-			
Chewability	0.447	0.314**	0.104	-		
Granularity/roughness	-0.058	0.442*	-0.065	0.107	-	
Melting in the mouth	0.174	0.208	-0.066	0.200	-0.010	-

***: *p*< .05; **:*p*< .01**

After examining the correlation analysis findings pertaining to the texture characteristics of standard chocolate including hazelnuts, a highly significant and positive association (p<.01) was observed between the parameters of hardness and chewiness. Furthermore, a statistically significant and positive correlation (p<.05) has been observed between the hardness and granularity/roughness indices, as seen in Table 4.

Table 5. Texture profile correlation of hazelnut vegan chocolates

Variables	Softness	Hardness	Stickiness	Chewability	Granularity /roughness	Melting in the mouth
Softness	-					
Hardness	-0.125	-				
Stickiness	0.104	0.238	-			
Chewability	0.217	0.319	-0.041	-		
Granularity/roughness	-0.015	-0.010	0.105	0.377*	-	
Melting in the mouth	0.399*	0.120	0.041	0.620**	0.447*	-

***: *p*< .05; **: *p*< .01**

After evaluating the outcomes of the correlation study conducted on the textures of vegan chocolate including hazelnuts, it is observed that there exists a statistically significant and positive association (p<.05) between the attributes of softness and melting in the mouth. Furthermore, a statistically significant and positive correlation (p<.05) exists between the attribute of chewiness and the characteristics of granularity and roughness. In addition, a significant and statistically significant association was observed between granularity/ roughness (p<.05). The analysis revealed an extremely major and positive connection (p<.01) between chewability and the phenomenon of melting in the mouth, as presented in Table 5.

Table 6. One-way anova result of texture properties of chocolate samples

Texture Properties	Examples	N	Mean	Std. Deviation	Std. Error	Sig. (p)
Softness	SC	30	2.233	1.147	0.104	.001*
	VC	30	3.054	0.559	0.175	
	SHC	30	2.104	1.041	0.190	
	VHC	30	3.100	1.093	0.199	
Hardness	SC	30	3.175	1.284	0.117	.228
	VC	30	2.666	1.493	0.272	
	SHC	30	3.433	1.072	0.195	
	VHC	30	2.133	1.105	0.201	
Stickiness	SC	30	2.166	1.063	0.097	.777
	VC	30	3.366	0.985	0.179	
	SHC	30	2.066	1.142	0.208	
	VHC	30	2.983	1.124	0.205	
Chewability	SC	30	3.666	0.998	0.091	.120
	VC	30	2.333	1.124	0.205	
	SHC	30	3.633	0.889	0.162	

	VHC	30	3.766	0.971	0.177	
Granularity/ roughness	SC	30	3.700	1.213	0.110	.608
	VC	30	3.266	1.241	0.226	
	SHC	30	3.833	1.085	0.198	
	VHC	30	2.833	1.019	0.186	
Melting in the mouth	SC	30	3.766	0.923	0.084	.066
	VC	30	3.766	0.971	0.177	
	SHC	30	3.600	0.855	0.156	
	VHC	30	3.566	0.976	0.173	

***: p< .05**

By analysing the analytical results pertaining to the texture attributes of the chocolate varieties mentioned in Table 6, a notable difference in the perceived softness parameter across the different types of chocolate is observed, with statistical significance (p<.05). The data reveals that the mean softness values for standard chocolate and chocolate with hazelnuts are comparatively lower than those for vegan chocolate and vegan chocolate with hazelnuts.

Although no significant difference was determined, VC exhibited lower chewability than other samples. VC and VHC correlation analyzes revealed that chewiness was largely negatively affected by stickiness (Table 4 and Table 5). The results that samples felt more softness and stickiness felt less chewiness. The melting in the mouth sensation perceived in vegan hazelnut chocolate led to a higher perception of chewiness, and the perception of higher chewiness led to a higher perception as granularity/roughness.

The perception of chocolate as soft has been observed to enhance the perceived rate of melting in the mouth. Research conducted by Lemarcq et al. (2022) showed that this phenomenon diminishes the sensation of chewiness in chocolate by diminishing the perception of granularity or roughness. Furthermore, Lemarcq et al. (2022) found that the relationship between the softness parameter and the stickiness and chewiness parameters revealed that the heightened softness parameter in chocolate led to an increased perception of stickiness, consequently diminishing the perceived chewiness of the chocolate. Hence, in accordance with the findings obtained, the correlation between these variables was assessed as a predictable occurrence. Previous research has shown that the amount of cocoa butter used in the manufacturing of chocolate improves its mouth-melting qualities, thereby enhancing the ease of chewing and perceived stickiness (Wollgarten et al., 2016; Limbargo et al., 2017). Past study has indicated that altering the texture of chocolate to a softer consistency results in a reduction in perceived graininess or roughness. According to Bangun et al. (2022), The findings in this regard appear to exhibit an extent of overlap with the outcomes of prior investigations. Dark chocolates exhibit a more solid consistency, leading to a heightened feeling of granularity or roughness in the chocolate. Hence, this particular attribute enhances its masticability largely (Andrae-Nıghtıngale and Engeseth, 2009). Additionally, it is thought that the hazelnuts added to the chocolate cause the chocolate to feel harder.

Flavor Profile

The flavor profile encompasses various qualities, including sweetness, cocoa taste, oily taste, bitterness, after mouthfeel, and unpleasant taste parameters. Incorporation of a hazelnut taste parameter was undertaken for the purpose of assessing hazelnut samples within the framework of FPA features.

Table 7. FPA correlation of standard chocolates

Variables	Softness	Hardness	Stickiness	Chewability	Granularity/ roughness	Melting in the mouth
Sweetness	-					
Cocoa Flavor	0.348**	-				
Oily Taste	0.318	0.212*	-			
Bitter Taste	-0.007	0.419*	0.211	-		
After Taste	0.452	0.249	0.178	0.150	-	
Unpleasant Flavor	0.226	0.009	0.144	0.002	0.259	-

***: p< .05; **:p< .01**

Upon analysing the correlation analysis results of the FPA features of standart chocolate, a highly significant and positive association (p <.01) was observed between the sweetness and cocoa taste parameters.

Furthermore, a statistically significant and positive correlation (*p<.05*) exists between the sensory attributes of cocoa taste and oily taste. Furthermore, a statistically significant and positive correlation (*p<.05*) was observed between the sensory perception of cocoa taste and the bitter taste attributes, as indicated in Table 7.

Table 8. FPA correlation of vegan chocolates

Variables	Softness	Hardness	Stickiness	Chewability	Granularity/ roughness	Melting in the mouth
Sweetness	-					
Cocoa Flavor	0.239	-				
Oily Taste	0.234	0.221	-			
Bitter Taste	-0.192	0.382*	0.140	-		
After Taste	0.379*	0.030	0.142	0.179	-	
Unpleasant Flavor	0.301	-0.125	0.114	-0.135	0.433*	-

: *p< .05*; **: *p< .01

Upon analysing the correlation results of the analysis pertaining to the FPA characteristics of vegan chocolate, a statistically significant and positive association (*p*<.05) is seen between the attributes of sweetness and after taste parameters. Furthermore, a statistically significant and positive correlation (*p*<.05) was observed between the sensory attributes of cacao taste and bitter taste. In addition, a notable and statistically significant (*p*<.01) correlation was identified between after taste and the unpleasant flavor parameters, as seen in Table 8.

Table 9. FPA correlation of hazelnut standard chocolate

Variables	Softness	Hardness	Stickiness	Chewability	Granularity/ roughness	Melting in the mouth
Sweetness	-					
Cocoa Flavor	0.469**	-				
Oily Taste	0.307	0.012	-			
Bitter Taste	0.401*	0.345*	0.306	-		
After Taste	-0.014	0.214	0.543**	-0.115	-	
Unpleasant Flavor	0.574**	0.279	0.320	0.326		-
Sweetness	0.253	0.165	0.382*	-0.061	0.335	0.213

: *p< .05* , **:*p< .01

Based on the correlation findings pertaining to the FPA characteristics of standard chocolate, including hazelnuts, it was observed that the sweetness attribute was notably and strongly influenced by the cocoa taste (*p*<.01), bitter taste (*p*<.05), after-eating mouth feeling (*p<.01*), and unpleasant taste parameters (*p*<.01). A correlation between variables was identified. Furthermore, a significant and positive correlation (*p*<.05) was identified between the variables of oily taste and unpleasant taste. Furthermore, a statistically significant and positive correlation (*p*<.01) was observed between the characteristics of oily taste and hazelnut taste, as indicated in Table 9.

Table 10. FPA correlation of hazelnut vegan chocolate

Variables	Softness	Hardness	Stickiness	Chewability	Granularity/ roughness	Melting in the mouth
Sweetness	-					
Cocoa Flavor	0.451*	-				
Oily Taste	0.584	0.316**	-			
Bitter Taste	-0.128	0.108	0.164	-		
After Taste	0.440	0.419	0.244	0.201	-	
Unpleasant Flavor	0.579**	0.369	0.129*	-0.159		-
Sweetness	-0.013	0.050	-0.027	0.080	0.322	0.216*

: *p< .05* , **:*p< .01

Upon analysing the correlation findings pertaining to the FPA characteristics of vegan chocolate including hazelnuts, a highly significant and positive association (*p*<.01) was observed between the attribute of sweetness, the cocoa taste (*p*<.05), and the post-tasting mouthfeel parameters. Furthermore, a statistically significant and positive correlation (*p*<.05) was observed between the parameter of oily taste and the sensory perception of cacao taste (p<.01), as well as the post-tasting mouthfeel parameters. Additionally, it was established that there existed a statistically significant and positive correlation (p < .01) between the after taste and the parameters associated with unpleasant taste, as seen in Table 10.

Table 11. One-way ANOVA result of fpa properties of chocolate samples

FPA Properties	Examples	N	Mean	Std. Deviation	Std. Error	Sig. (p)
Sweetness	SC	30	3.241	0.786	0.146	.674
	VC	30	3.379	0.902	0.167	
	SHC	30	3.391	0.910	0.083	
	VHC	30	3.556	0.935	0.170	
Cocoa Taste	SC	30	3.586	1.052	0.195	.138
	VC	30	3.379	1.082	0.201	
	SHC	30	3.316	1.209	0.110	
	VHC	30	3.100	0.922	0.168	
Oily Taste	SC	30	3.413	1.086	0.201	.368
	VC	30	3.137	1.025	0.190	
	SHC	30	4.200	1.033	0.094	
	VHC	30	3.000	0.946	0.172	
Bitter Taste	SC	30	3.896	1.205	0.223	.027*
	VC	30	3.316	1.182	0.219	
	SHC	30	3.448	1.209	1.110	
	VHC	30	2.933	1.112	0.203	
Hazelnut Taste	SC	-	-	-	-	.081
	VC	-	-	-	-	
	SHC	30	3.333	0.802	0.146	
	VHC	30	3.866	1.195	0.218	
After Taste	SC	30	3.517	1.089	0.202	.936
	VC	30	3.482	0.085	0.268	
	SHC	30	3.366	1.104	0.201	
	VHC	30	3.600	1.132	0.206	
Unpleasant Taste	SC	30	2.133	0.819	0.149	.115
	VC	30	2.700	1.184	0.220	
	SHC	30	2.758	1.313	0.119	
	VHC	30	2.600	1.132	0.206	

***: *p*< .05**

The results of the analysis of the FPA properties of chocolate varieties are given in Table 11. It was determined that the only parameter with a significant difference between chocolate types was bitter taste (p<.05). When the averages are examined, it is seen that the bitter taste parameter is higher in standard chocolate varieties than in vegan chocolate varieties.

According to Lemarcq et al. (2022), the perception of bitterness in chocolate is influenced by the quantity of cocoa flavor present. The high level of fat in cocoa beans contributes to a correlation between the taste of cocoa and the feeling of oiliness. Moreover, it is expected that the flavor profile of dark chocolate will mostly exhibit cocoa notes (Escobar et al., 2021). The sweetness parameter felt in chocolate negatively affects the perception of the mouthfeel after tasting the chocolate, paving the way for the unpleasant taste parameter to be felt more dominantly. Because excessive sweetness makes dark chocolate feel more bitter (Palazzo and Bolini, 2014).

Previous research conducted by Palozzo and Bolini (2013) has established that the taste of cocoa has an impact on the parameter of sweetness. Hence, it is anticipated that there exists a correlation between the perception of sweetness and the taste of cocoa. Moreover, the presence of a higher fat content in hazelnuts resulted in an increased perception of oiliness in the chocolate (Alasalvar et al., 2003). Simultaneously, the heightened presence of fatty flavor mitigated the perception of unpleasant taste. This resulted in an enhanced perception of the deliciousness of chocolate (Rashid et al., 2017).

The presence of an oily taste in the chocolate had a beneficial impact on the mouthfeel parameter, resulting in a heightened perception of deliciousness (da Veiga Moreira et al., 2018).

Upon examining the nutritional information of normal chocolate and vegan chocolates, it has been noted that the standard chocolate exhibits a higher fibre content. The aforementioned disparity has been noted to impact the softness parameter (Uysal et al., 2007). Moreover, upon closer examination of the product composition, it becomes evident that conventional dark chocolate incorporates the inclusion of milk powder. Hence, it is postulated that the present disparity has emerged.

It is thought that the difference in bitterness of samples arises because cocoa butter increases the amount of cocoa and bitter taste felt in chocolate (Prindiville et al., 2000; Syed et al., 2018).

According to a survey conducted by Grassian (2020), there is a prevailing perception among consumers that vegan products are of inferior quality and lack flavor. Nevertheless, upon careful evaluation, it becomes apparent that the taste profiles of vegan chocolates closely resemble those of conventional chocolates. Consequently, this finding illustrates that those who do not adhere to a vegan diet can partake in the consumption of vegan chocolates without apprehension regarding their flavor.

General acceptance

Fig. 2. Sensory profiles of chocolate samples, texture analysis results (a), fpa results (b)

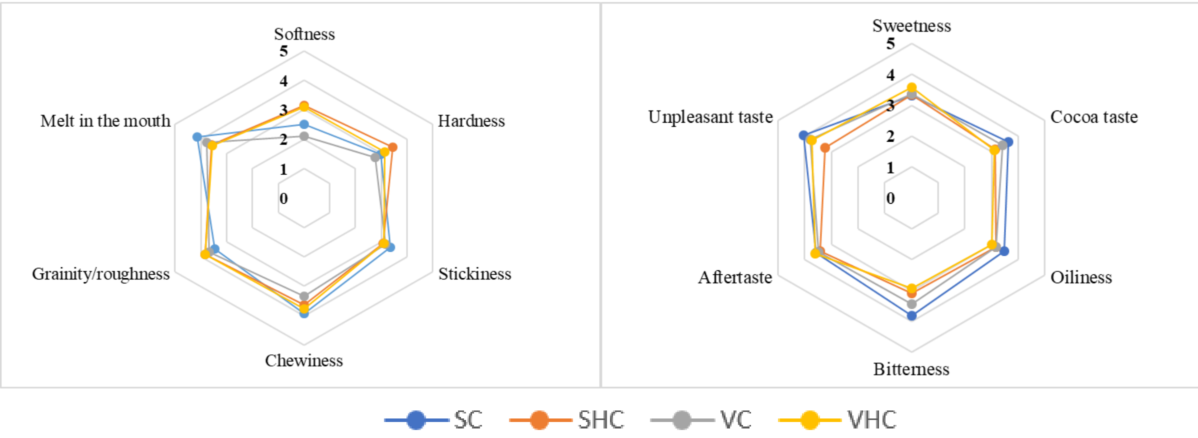


Table 12. Hedonic test one-way anova result of chocolate samples

Examples	N	Mean	Std. Deviation	Std. Mistake	Sig. (p)
SC	30	3.430	0.912	0.168	
VC	30	3.273	0.905	0.175	
SHC	30	3.076	0.986	0.231	.326
VHC	30	3.430	0.972	0.249	

Figure 2 shows that results of FPA and texture analysis of chocolate samples. Upon examination of the data table, it was established that there existed no statistically significant disparity in the degrees of preference among various types of chocolate (Table 12). As shown in Figure 3, the data illustrates that the preference rates for both regular chocolate and hazelnut-infused vegan chocolate was equivalent. It is worth mentioning that the chocolate variant including hazelnuts was the least preferred among individuals. The observed outcomes suggest that the presence of oily flavor and unpleasant taste parameters may be responsible for the current circumstances. Furthermore, it is hypothesised that the heightened sensory experience of hazelnut flavor and sweetness attributes in vegan chocolate including hazelnuts contributes to an elevated level of satisfaction with vegan chocolate containing hazelnuts. McClure et al., have been reported that sweetness and cocoa density increased chocolate preference and acceptability (McClure et al., 2022).

Fig. 3. General acceptability of chocolates

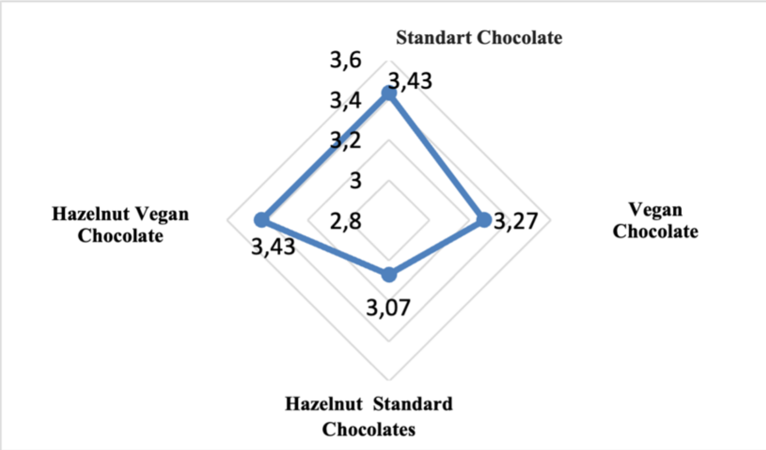
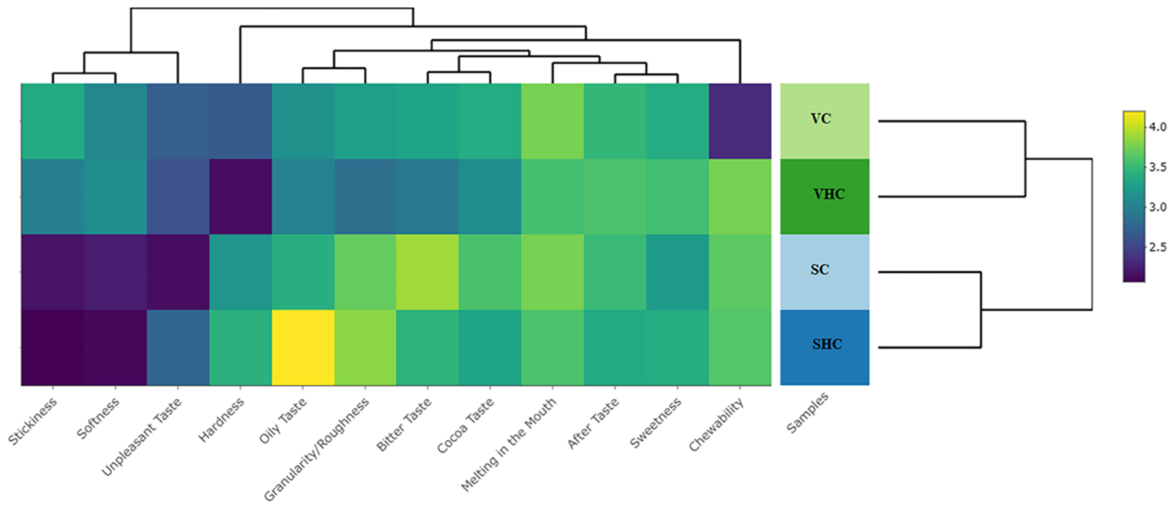


Fig. 4. Comparison of consumer demands in terms of taste and texture features



The heatmap, where consumer demands are compared in terms of basic taste and texture parameters that make up the general appreciation, can be seen in Figure 4. As a result of consumer evaluations, SC and SHC are more similar to each other in terms of general taste and texture properties. Furthermore, VC and VHC taste and texture characteristics were similar.

While stickiness and softness were perceived as more evident in vegan chocolate samples, on the contrary, hardness was perceived as less. It is thought to originate from the plant-based protein sources included in the composition of vegan chocolate samples. Stickiness and softness in vegan-based products have also been reported in previous studies (Adhikari et al., 2001; McClements et al., 2021). However, the effect of these features on consumability and chewability was perceived to be significantly lower in VC, unlike other samples. Chewiness was perceived at a significant level in all three other chocolate samples. Granularity/roughness was more perceived in standard chocolate samples than in vegan chocolate samples. Although there is no significant difference, melting in the mouth was determined to be higher in vegan and standard chocolate samples that do not contain hazelnuts. While the perception of hardness was more evident in standard chocolate samples, softness was perceived more clearly in vegan chocolate samples. Perception of oily taste in chocolate, usually caused by cocoa and cocoa butter was perceived more in SHC than in other chocolates. However, cocoa and bitter taste perceptions were perceived similarly in all products. It is thought that the hazelnut-derived granularity/roughness found in SHC increases the perception of oily taste. After taste sensation is largely similar to cocoa taste perception. The heatmap reveals that mouthfeel is largely influenced by cocoa and oily taste, considering all chocolate reviews.

Conclusion

The study aimed to investigate the similarities and differences between vegan chocolate, a product that has gained popularity due to the rise in vegan food options, and standard chocolate. The findings revealed a notable distinction in terms of softness between the samples when assessing their texture properties. Based on the findings, it was concluded that conventional chocolates exhibited more hardness compared to vegan chocolate. There was no discernible disparity observed among the various parameters. According to the data acquired from the flavor profile analysis (FPA), there was a substantial difference in the bitter taste attribute. When the data was averaged, it was discovered that the bitter taste parameter was higher in regular chocolate types than in vegan chocolate varieties. This study, which focused on dark chocolate, determined that there was no discernible distinction between vegan and normal chocolate in terms of other flavor characteristics. Furthermore, it was concluded that there existed no statistically significant disparity in the preference levels between vegan and standard chocolates. Chocolates exhibit robust antioxidant properties and possess a considerable amount of phenolic compounds, both of which confer health benefits. Consequently, the inclusion of vegan chocolate in one's diet may offer nutritional advantages and contribute to overall well-being. Furthermore, the increasing consumer demand for better food alternatives serves to reinforce the desirability of vegan chocolate. Vegan chocolate is often regarded as a viable choice for individuals adhering to a vegan lifestyle or those with lactose sensitivity, as it offers a viable alternative for indulging in chocolate consumption.

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