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SENSORY PROFILE OF A SPECIALTY SICILIAN CHOCOLATE

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ABSTRACT

In this study a sensory profile definition by a trained panel and instrumental measures determination (pH, acidity, reducing sugar content) were carried out on the Sicilian chocolate known as "Modica" that is a niche cacao product spiced (cinnamon, vanilla) so as to obtain the Protected Geographical Indication (PGI) branding for such a product. Sensory and instrumental data were also submitted to statistical analysis. The chocolate of Modica has shown a sensory profile different from other industrial products; in fact it is unique for the presence of sugar crystals and its gritty texture resulting from the manner of its production.

- Key words: chocolate, instrumental determination, sensory profile, Modica, spicy -

INTRODUCTION

Chocolate originates from Mexico where the Mayas, Incas and Aztecs cultivated the cacao tree (*Theobroma cacao*) preparing this product only on special occasions (COE and COE, 1996). While we eat chocolate the pleasure centres of our brain are activated. One typical quality of chocolate is its melt point; it is solid at ambient temperature but it melts in the mouth and it is dissolved in saliva allowing a clear final assessment of its texture.

Particle size distribution and ingredient composition of chocolate (sugar and cocoa about 70% total in a continuous fat phase) play an important role in shaping its rheological behaviour and sensory perception (AFOAKWA *et al.*, 2007).

In the past chocolate was seen only as a food of sensual pleasure with negative effects on health, however, today chocolate has been revaluated positively, thanks to greater nutritional information that discredits many fallacies. Despite high lipid and sugar content, its consumption has some beneficial effects on the human diet; cocoa is rich in antioxidants, above all polyphenols and minerals such as potassium, magnesium, copper and iron, so its intake may be useful in dietary deficiencies or may balance low levels of neurotransmitters involved in the regulation of food intake (serotonin and dopamine) (BRUINSMA, 1999). Thus it is not surprising that chocolate has always been the most commonly and intensely craved food in western cultures (WEINGARTEN and ELSTON, 1990; OSMAN and SOBAL, 2006).

Switzerland ranks first among the world's consumers of chocolate, it is a "chocolate heavy user country" followed by Belgium and Denmark; Italy only ranks 12th place with a constant growing trend, in fact, the per capita consumption passed from 3.2 kg in 1997 to 4.3 kg in 2006 (+36.4%) (BOMMEZZADRI, 2007).

In the choices of the consumer, tradition has prevailed: as for bars, milk chocolate is always the best seller, and there is a continuing rise in dark chocolate sales, while white chocolate sales are declining (BOMMEZZADRI, 2007).

Differences in the sensory characters of chocolate can be ascribed to the use of different cocoa types, i.e. flavour quality of chocolate usually depends on the origin of the cocoa beans (JINAP *et al.*, 1995), variations in ingredient proportions and in the processing methods (JACKSON, 1999) that differ in relation to national consumer preferences and producer company practices (BECKETT, 2000; WHITEFIELD, 2005). In this panorama there are niche chocolates that offer variety in sensory characteristics. For these products it is useful to define the standard of sensory identity through analyzing the characteristics of locally crafted chocolates. In this research the chocolate of Modica has been characterized.

During the Spanish domination (1516-1713), an Aztec recipe to prepare the "xocoatl", cocoa mass mixed with vanilla or cinnamon and sugar, was transferred to the inhabitants of the county of Modica (Sicily) as a gift of fidelity. The formula of this chocolate was lost and only through historical sources the original recipe has been recovered. Until 1992 the chocolate of Modica was quite unknown, it was mainly consumed at a local level with a production of a few thousand bars/year. Unlike other chocolate commercial products, this type of chocolate has often been considered as a new product (CIUFFOLETTI and CRESTI, 2004).

Today some techniques and ingredients are employed to prepare a primitive type of chocolate bar whose ancient formula may be exploited to put on the market as a new product. Winning strategies of correct visibility regarding marketing and packaging gave a new status to the product. In fact, 300.000 bars/year of production have entered into national distribution only in specialized shops. One of the greatest producers of chocolate of Modica has had a 25% growth trend in 2006 and the chocolate spiced with cinnamon/vanilla has been the most sold with a 10% growth trend (BOMMEZZADRI, 2007).

With reference to the chocolate production technology (roasting of cocoa beans, mixing, conching, and tempering) the chocolate of Modica processing method is very simple.

For the production of chocolate of Modica, the Disciplinary (2003) compiled by the Consortium of Guardianship foresees that a mass of cocoa heated to 45°C and mixed with sugar and spices (vanilla, cinnamon, chilli) without addition of emulsifiers is manually worked with stone tools at a constant temperature that does not allow the melting of sugar crystals. By subsequent cold tempering the cocoa butter consolidates and the product is ready to be formed in rectangular shape (www.cioccolatomodica.it).

Since there are no scientific publications about this product and considering that the characteristics of chocolate have been assessed by sensory and instrumental measures (GUINARD and MAZZUCCHELLI, 1999), the aim of this study is to underline the diversity of this chocolate percepted by the consumers safeguarding its identity. The memory of this chocolate was lost and only through historical sources the original recipe has been discovered. For this ancient chocolate that is produced by a number of craft-made producers, the definition of the sensory profile as well as the analytical measures of pH, titratable acidity and reducing sugar on the cinnamon and vanilla chocolate of Modica can constitute a fundamental step to identify the parameters that should be included in the PGI disciplinary (Reg. CEE, 1992). This step constitutes a winning strategy so that the memory becomes enterprise giving a new status to the product.

MATERIALS AND METHODS

Sampling

Samples analyzed were: 3 craft-made chocolates of Modica spiced with cinnamon (Bc, DAc, Sc), 5 craft-made chocolates of Modica spiced with vanilla (Bv, Ev, Cv, Rv, Sv) obtained from different producers, a craft-made chocolate of Modica without spices (BNA), a sample of dark chocolate by intermediate sensory characteristics due to muscovado sugar (D), and a commercial chocolate (N) (extra bitter Italian chocolate with 72% of cocoa), indicated as Nc and Nv in the sensory evaluation, respectively of cinnamon and vanilla chocolate of Modica. The chocolate samples were brought to room temperature (25°±0.5°C) prior to chemical and sensory analyses.

Sensory evaluation

A descriptive panel of 8 judges (5 females and 3 males, aged between 25 and 40 years) selected from students and university staff was utilized to define the sensory profile (UNI 10957, 2003). The judges were trained in 12 sessions, each approximately 1 h in duration, using both commercial and Modica craft-made chocolate, in order to develop a common vocabulary for the description of the sensory attributes of dark chocolate samples and to familiarize the panellists with scales and procedures. Each attribute term was extensively described and explained to avoid any doubt about the relevant meaning. The panel had agreed on attributes utilized including a list of reference standards for each participant (Table 1). These attributes correspond to the highest intensity score on the rating scale used, and were established according to a previous study (LANZA *et al.,* 2004).

Experimental design

To reduce perception fatigue of the judges, the working plan fixed the sensory evaluation of the three cinnamon and the five vanilla chocolate in triplicate at different times. In every session, the set submitted to judges was composed of four samples: the sample to evaluate and as reference standards chocolate of Modica without spices, chocolate with muscovado sugar and commercial chocolate.

Random samples, prepared by cutting the chocolate bar into squares were evaluated in triplicate; this was performed by assigning to every attribute a score between 1 (absence of corresponding sensation) and 9 (extremely intense) in individual booths under incandescent white lighting in the sensory laboratory of the DOFATA Department. Within each session the design was balanced for carry over effect among samples and session (PAGLIARINI, 2002).

Water at room temperature was used to rinse after sample tasting. A computerized data collection program was used (FIZZ Software Solutions for sensory Analysis and Consumer Tests, Biosystemes, Couternon, France).

pH and titratable acidity determination

The pH and titratable acidity were determined, in triplicate, as described by JINAP and DIMICK (1990): 10 g samples were pulverized in 90 mL boiling water.

The extract was filtered and the pH was measured.

Titratable acidity was determined on the extract with 0.10 M sodium hydroxide to an endpoint of pH 8.0.

Reducing sugars

The concentration of reducing sugar was determined by the Fehling titration method on the extract after the inversion of sucrose with sulphuric acid (AOAC, 1990).

Statistical analysis

The sensory data for each attribute were submitted to Analysis of the Variance (ANOVA) with samples (S), judges (J), replicates (R) and their relevant interactions J x S, S x R, J x R as effects by using SAS/STAT® statistical software package version 9.1 (SAS Institute Inc., Cary, USA). The significance of these effects was tested with the F test. The mean values were submitted to the multiple comparison test using the procedure LSD (Least Significant Difference) that enables the determination of the attributes that differentiate the samples.

Principal Component Analysis (PCA) was also applied to sensory and instrumental means data in order to interpret differences among chocolate samples using THE UNSCRAMBLER® statistical software package version 9.2 (Camo As, Trondheim, Norway).

RESULTS AND DISCUSSION

The mean values of the instrumental data are reported in Table 2. The different values of pH and titratable acidity among samples can be ascribed to the different origins of the cocoa mass utilized by the different producers. The large range in reducing sugar values for these products are indicative of the absence of a standardized process for producing chocolate of Modica.

During their training period the judges produced a list of attributes that were useful to define the sensory profile. Among the terms generated, those with a percentage of elicitation greater than 70% are included in the evaluation card: Colour uniformity, Bright and Presence of crys-

Table 1 - List of sensory attributes evaluated, their definitions and corresponding standards.

Attribute	Definition	Reference
Appearance		
Bright	Perceived color of an object indicating the relationship between reflected and absorbed light	Dark chocolate(Perugina*®)
Presence of crystals	Amount of sugar crystals present in the surface of sample (appearance)	Chocolate of Modica
Aroma		
Butter aroma	Characteristic aroma of butter perceived with the sense of smell	White chocolate (Milka®)
Cocoa	Characteristic aroma of cocoa perceived with the sense of smell	Cocoa powder (Perugina)
Cinnamon/	Characteristic aroma of cinnamon perceived with the sense of smell	Dark chocolate (Perugina) with 1% of cinnamon aroma
Vanilla	Characteristic aroma of vanilla perceived with the sense of smell	Dark chocolate (Perugina) with 1% of vanilla aroma
Chocolate	Characteristic aroma of chocolate perceived with the sense of smell	Dark chocolate (Perugina)
Taste		
Sour	One of the four basic tastes caused by aqueous solutions of acid compounds perceived on the tongue	Dark chocolate (Perugina) with 5% of citric acid
Bitter	One of the four basic tastes caused by aqueous solutions of bitter compounds perceived on the tongue	Dark chocolate (Lindt**®)
Sweet	One of the four basic tastes caused by aqueous solutions of sweet compounds perceived on the tongue	Dark chocolate (Perugina) with 10% of sucrose
Flavour		
Cocoa	Characteristic flavour of cocoa perceived with the swallowing	Cocoa powder (Perugina)
Cinnamon	Characteristic flavour of cinnamon perceived with the swallowing	Dark chocolate (Perugina) with 1% of cinnamon/vanilla aroma
Vanilla	Characteristic flavour of vanilla perceived with the swallowing	Dark chocolate (Perugina) with 1% of vanilla aroma
Chocolate	Characteristic flavour of chocolate perceived with the swallowing	Dark chocolate (Perugina)
Mouthfeel		
Astringent	Sensory perception in the oral cavity that may include drying sensation, and roughing of the oral tissue	Dark chocolate (Perugina) with 1% of tartaric acid
Texture		
Firm	Strength required to compress a substance between the molars	Chocolate of Modica
Cohesive	Degree of compression (between the teeth) obtained prior to breaking of the product	Dark chocolate (Lindt)
Adhesive	Strength required to remove product completely from palate using tongue, after compression of the sample between tongue and palate	Dark chocolate (Lindt)
Melting	A phase change in the mouth due to the increasing of temperature in oral cavity	Dark chocolate (Perugina)
Friable	Strength with which a product crumbles and flakes	Dark chocolate (Perugina) with 20% of cereal powder
Gritty	Amount of small particles perceived in the mouth when biting the sample	Dark chocolate (Perugina) with 20% of "Pavesini"® biscuits

*dark chocolate with 60% of cocoa mass; ** dark chocolate with 99% of cocoa mass.

Table 2 - Instrumental means data.

Sample	pH	Std. dev.	Tritatable acidity Meq NaOH/g	Std. dev.	Reducing sugar g/100 g	Std. dev.
N	5.70	±0.18	4.30	±0.35	28.00	±0.05
BNA	5.92	±0.04	2.73	±0.02	55.44	±3.09
D	5.51	±0.01	4.32	±0.00	40.97	±0.01
Cinnamon						
Bc	5.74	±0.02	3.03	±0.02	40.41	±0.79
Dac	6.78	±0.06	1.21	±0.12	67.11	±1.56
Sc	5.77	±0.02	2.73	±0.02	41.68	±0.24
Vanilla						
Bv	5.76	±0.08	2.81	±0.14	54.90	±0.49
Ev	6.92	±0.08	0.99	±0.08	62.17	±0.01
Cv	6.94	±0.06	1.28	±0.11	58.48	±1.38
Rv	6.97	±0.10	1.07	±0.06	64.42	±2.03
Sv	6.08	±0.00	2.12	±0.07	62.35	±1.26

tals (appearance), Butter Aroma, Cocoa Aroma, Chocolate Aroma (olfactive), Sour, Bitter, Sweet (gustative), Cocoa Flavour, Chocolate Flavour (flavour), Astringent (mouthfeel), Firm, Cohesive, Adhesive, Melting, Friable, Gritty (texture), for the cinnamon samples while for the vanilla chocolates they were classified by their vanilla aroma and flavour, however for the vanilla samples the judges did not elicit the attributes Colour uniformity, Bright, Sour, Astringent, and Friable.

The results of ANOVA for cinnamon chocolates (Table 3) showed significant differences among the samples for all the attributes with the exception of Cocoa flavour and Melting. The judge effect indicated significant differences for many attributes however the replication effect was not significant except for Cocoa aroma attribute. The interactions SxJ revealed significant differences with the exception of Colour uniformity, Bright, Sweet, Cinnamon flavour, Adhesive. The interactions S x R showed a good homogeneity of the samples during replicates, with the exception of Bright and Cinnamon aroma, and finally, the interactions J x R underlined a good reliability of the answers furnished by the judges.

ANOVA of vanilla chocolate (Table 4) showed significant differences among samples for all of the attributes, except that for Cocoa aroma and flavour and Melting. The judge effect indicated significant differences for all attributes however the replication effect was not significant except for the Presence of crystals attribute. The interactions SxJ reveal significant differences, except that for Chocolate aroma and flavour.

Table 3 - Influence of samples (6), judges (8) and replications (3) on the nineteen descriptors for cinnamon chocolate.

	F value					
Attributes	Samples	Judges	Replications	SxJ	SxR	JxR
Colour uniformity	110.45***	0.89 n.s.	1.90 n.s.	1.07 n.s.	1.23 n.s.	1.38 n.s.
Bright	97.10***	1.29 n.s.	2.26 n.s.	1.12 n.s.	1.97*	0.94 n.s.
Presence of crystals	119.25***	3.60**	0.42 n.s.	3.21***	0.27 n.s.	0.58 n.s.
Cocoa aroma	2.52*	4.37***	3.73*	1.67*	0.97 n.s.	0.50 n.s.
Chocolate aroma	15.60***	1.57 n.s.	0.05 n.s.	1.65*	0.50 n.s.	0.48 n.s.
Cinnamon aroma	109.54***	0.53 n.s.	0.42 n.s.	2.51***	2.12*	1.40 n.s.
Butter aroma	4.12**	0.93 n.s.	0.46 n.s.	2.31**	1.04 n.s.	0.76 n.s.
Sweet	28.13***	1.46 n.s.	0.44 n.s.	1.08 n.s.	0.42 n.s.	0.30 n.s.
Sour	7.30***	0.68 n.s.	0.32 n.s.	3.20***	1.44 n.s.	0.80 n.s.
Cocoa flavour	0.72 n.s.	2.18*	0.62 n.s.	1.99**	1.24 n.s.	0.43 n.s.
Chocolate flavour	14.51***	3.98***	0.73 n.s.	1.83*	1.20 n.s.	0.53 n.s.
Cinnamon flavour	76.50***	0.75 n.s.	0.36 n.s.	1.45 n.s.	1.21 n.s.	0.52 n.s.
Astringent	10.44***	2.34*	0.39 n.s.	3.64***	0.40 n.s.	1.43 n.s.
Firm	5.31***	0.90 n.s.	1.33 n.s.	2.34**	0.83 n.s.	0.62 n.s.
Cohesive	8.93***	2.68*	0.29 n.s.	1.98**	1.10 n.s.	0.52 n.s.
Adhesive	6.11***	2.00 n.s.	1.46 n.s.	1.38 n.s.	0.49 n.s.	0.72 n.s.
Melting	2.25 n.s.	2.95**	2.09 n.s.	1.82*	0.85 n.s.	0.97 n.s.
Friable	71.12***	4.02***	0.09 n.s.	1.60*	0.49 n.s.	0.37 n.s.
Gritty	112.62***	4.04***	0.20 n.s.	3.69***	0.54 n.s.	1.06 n.s.

*** significant difference for $p \leq 0.001$; ** significant difference for $p \leq 0.01$; * significant difference for $p \leq 0.05$; n.s. no significant difference.

Table 4 - Influence of samples (8), judges (8) and replications (3) on the fourteen descriptors for vanilla chocolate.

	F value					
Attributes	**Samples**	**Judges**	**Replications**	**SxJ**	**SxR**	**JxR**
Presence of crystals	131.31***	38.64***	4.98**	4.50***	20.80***	0.87 n.s.
Cocoa aroma	1.73 n.s.	5.09***	0.71 n.s.	2.72***	1.67 n.s.	1.35 n.s.
Chocolate aroma	22.32***	12.29***	1.04 n.s.	1.29 n.s.	0.80 n.s.	1.91*
Vanilla aroma	7.01***	11.09***	0.19 n.s.	2.58***	2.50**	0.85 n.s.
Butter aroma	3.14**	12.80***	1.22 n.s.	2.15***	1.44 n.s.	0.60 n.s.
Sweet	25.03***	27.60***	1.64 n.s.	2.53***	10.63***	0.61 n.s.
Cocoa flavour	1.40 n.s.	10.90***	0.03 n.s.	2.74***	0.99 n.s.	0.76 n.s.
Chocolate flavour	10.90***	10.38***	0.79 n.s.	1.40 n.s.	1.16 n.s.	1.09 n.s.
Vanilla flavour	9.75***	11.82***	1.39 n.s.	2.65***	2.48**	0.91 n.s.
Firm	2.91**	17.98***	0.83 n.s.	1.78**	0.62 n.s.	0.61 n.s.
Cohesive	3.33**	17.10***	0.06 n.s.	2.17***	0.81 n.s.	2.06*
Adhesive	5.57***	19.51***	0.88 n.s.	2.04**	1.25 n.s.	1.65 n.s.
Melting	1.40 n.s.	7.54***	0.61 n.s.	2.16***	1.92*	1.12 n.s.
Gritty	93.85***	36.90***	1.14 n.s.	5.26***	10.88***	1.14 n.s.

*** significant difference for $p \leq 0.001$; ** significant difference for $p \leq 0.01$; * significant difference for $p \leq 0.05$; n.s. no significant difference.

The interactions S x R did not show a good homogeneity of the samples during replicates, and finally, the interactions J x R underlined a good reliability of the answers furnished by the judges with the exception of Chocolate aroma and Cohesive.

The mean values of the samples' sensory data submitted to the multiple comparison test (LSD) were useful to determine what attributes differentiate the samples (Tables 5 and 6).

With respect to the cinnamon chocolate, the commercial sample (Nc) shows the highest mean score as far as Color uniformity, Bright, Butter aroma and Astringent attributes are concerned, while with respect to the vanilla samples, the commercial sample (Nv) shows the highest mean scores for Aroma and Chocolate Flavour, Butter Aroma and Adhesive attributes. Even if the samples of Modica have different rheological characteristics (Presence of crystals, Gritty

Table 5 - Mean of the score among the 19 sensory attributes for cinnamon and no spicy samples (6).

Attributes	**Bc**	**BNA**	**DAc**	**Sc**	**Dc**	**Nc**
Color uniformity	1.60^{a1}	2.54^{b}	5.10^{c}	6.85^{d}	7.33^{d}	8.42^{e}
Bright	1.58^{a}	1.95^{a}	4.85^{b}	6.29^{c}	6.46^{c}	7.43^{d}
Presence of crystals	7.90^{e}	7.42^{de}	6.54^{c}	6.98^{cd}	4.46^{b}	1.00^{a}
Cocoa aroma	4.52^{abc}	5.17^{c}	4.06^{a}	4.29^{ab}	4.88^{bc}	5.07^{bc}
Chocolate aroma	4.10^{bc}	2.83^{a}	3.46^{ab}	3.90^{bc}	4.58^{c}	6.31^{d}
Cinnamon aroma	4.83^{b}	1.00^{a}	5.71^{c}	6.13^{c}	1.00^{a}	1.00^{a}
Butter aroma	1.85^{a}	2.33^{a}	1.92^{a}	1.85^{a}	2.33^{a}	3.10^{b}
Sweet	7.06^{c}	6.42^{c}	6.79^{c}	6.44^{c}	4.25^{b}	3.28^{a}
Sour	2.42^{ab}	2.88^{b}	2.06^{a}	2.73^{ab}	4.00^{c}	3.10^{b}
Cocoa flavour	4.56	4.75	4.44	4.56	5.08	4.74
Chocolate flavour	4.08^{b}	2.79^{a}	3.92^{b}	3.88^{b}	4.46^{b}	6.11^{c}
Cinnamon flavour	4.42^{b}	1.00^{a}	5.52^{c}	6.35^{d}	1.00^{a}	1.00^{a}
Astringent	2.38^{a}	2.67^{a}	2.58^{a}	3.04^{a}	4.38^{b}	4.08^{b}
Firm	4.02^{a}	4.46^{ab}	5.40^{c}	5.50^{c}	5.42^{c}	5.07^{bc}
Cohesive	2.92^{a}	4.17^{b}	3.94^{b}	4.13^{b}	4.96^{c}	5.31^{c}
Adhesive	3.23^{a}	4.54^{c}	3.52^{ab}	4.06^{abc}	4.42^{bc}	5.57^{d}
Melting	4.77	4.92	5.40	5.42	5.29	5.83
Friable	6.86^{d}	5.63^{c}	6.90^{d}	6.71^{d}	3.96^{b}	1.39^{a}
Gritty	7.56^{d}	6.88^{c}	7.00^{cd}	6.73^{c}	4.33^{b}	1.14^{a}

[1]The values marked with different letters in the same line are significantly different ($p \leq 0.05$).

Table 6 - Mean of the score among the 14 sensory attributes for vanilla and no spicy samples (8).

Attributes	BNA	Bv	Ev	Cv	Dv	Rv	Sv	Nv
Presence of crystals	7.42^{e1}	6.84^{e}	7.33^{e}	5.44^{c}	5.04^{bc}	4.81^{b}	6.31^{d}	1.08^{a}
Cocoa aroma	5.17	5.33	4.81	4.60	5.63	5.00	4.94	4.92
Chocolate aroma	2.83^{a}	4.60^{cd}	3.71^{b}	4.33^{bc}	5.00^{d}	4.48^{cd}	4.96^{cd}	6.58^{e}
Vanilla aroma	1.00^{a}	2.35^{d}	2.02^{cd}	2.10^{cd}	1.71^{bc}	2.25^{d}	2.15^{cd}	1.50^{b}
Butter aroma	2.33^{a}	2.38^{a}	2.27^{a}	2.56^{a}	2.54^{a}	2.29^{a}	2.38^{a}	3.54^{b}
Sweet	6.42^{d}	6.10^{cd}	6.42^{d}	5.50^{b}	4.29^{a}	5.73^{bc}	6.34^{d}	3.79^{a}
Cocoa flavour	4.75	5.33	4.83	4.60	5.25	4.94	4.58	4.96
Chocolate flavour	2.79^{a}	4.58^{c}	3.65^{b}	4.17^{bc}	4.46^{c}	4.54^{c}	4.73^{c}	5.54^{d}
Vanilla flavour	1.00^{a}	2.19^{c}	1.81^{bc}	2.17^{c}	1.63^{b}	2.17^{c}	1.98^{bc}	1.13^{a}
Firm	4.46^{a}	5.54^{c}	4.81^{ab}	5.06^{abc}	5.54^{c}	5.46^{bc}	5.57^{c}	5.42^{bc}
Cohesive	4.17^{ab}	3.73^{a}	3.96^{ab}	4.34^{b}	4.13^{ab}	4.46^{b}	4.02^{ab}	5.17^{c}
Adhesive	4.54^{cd}	3.21^{a}	3.58^{ab}	4.04^{bc}	3.92^{bc}	4.19^{bc}	3.90^{abc}	5.13^{d}
Melting	4.92	5.73	5.65	5.46	5.21	5.38	5.79	5.17
Gritty	6.88^{d}	6.56^{d}	7.04^{d}	5.04^{b}	5.33^{bc}	4.83^{b}	5.65^{c}	1.04^{a}

[1]The values marked with different letters in the same line are significantly different ($p \leq 0.05$).

and Friable), they are not significantly different from commercial chocolate samples as for the intrinsic attributes of chocolate that is Melting and Cocoa flavour.

The next step regards the principal component analysis of all of the sensory and instrumental data of the cinnamon and vanilla samples in order to identify the importance of various attributes to discriminate among the samples obtaining a multidimensional space. Figures 1 and 2 report the principal component score plot and the principal component loading plot from chocolate sensory and analytical data, respectively.

The variance explained by the first two principal components was 75%. Figure 1 (score plot) shows the position of the samples in the 3 replicates. Since the distance among the replicates of the same product is very little, it can be affirmed that the results are reliable and that the judges have furnished their judgments in a consistent way. Furthermore, chocolate samples appear to be well separated in the space.

Moving left to right along the first component (explained variance 54%), commercial chocolate samples (N and D) are distinct from the Modica chocolate. The second component (explained variance 21%) distinguishes the cinnamon and not spicy samples from the vanilla chocolate.

Principal components loading were examined in order to identify the importance of various attributes in discriminating among the samples.

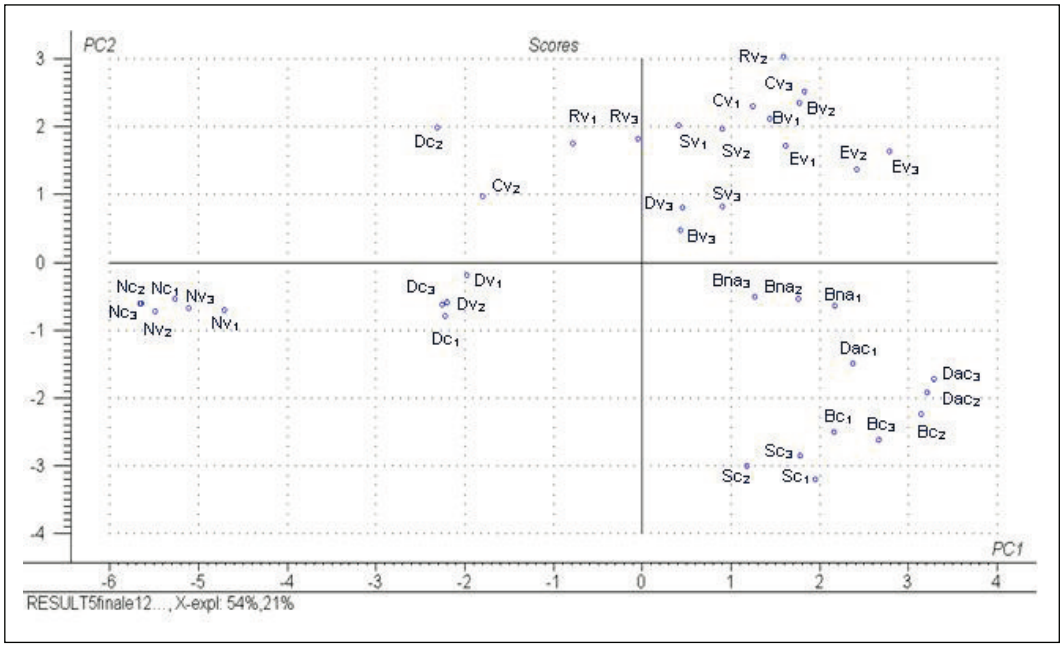

Fig. 1 - Score plot of chocolate samples.

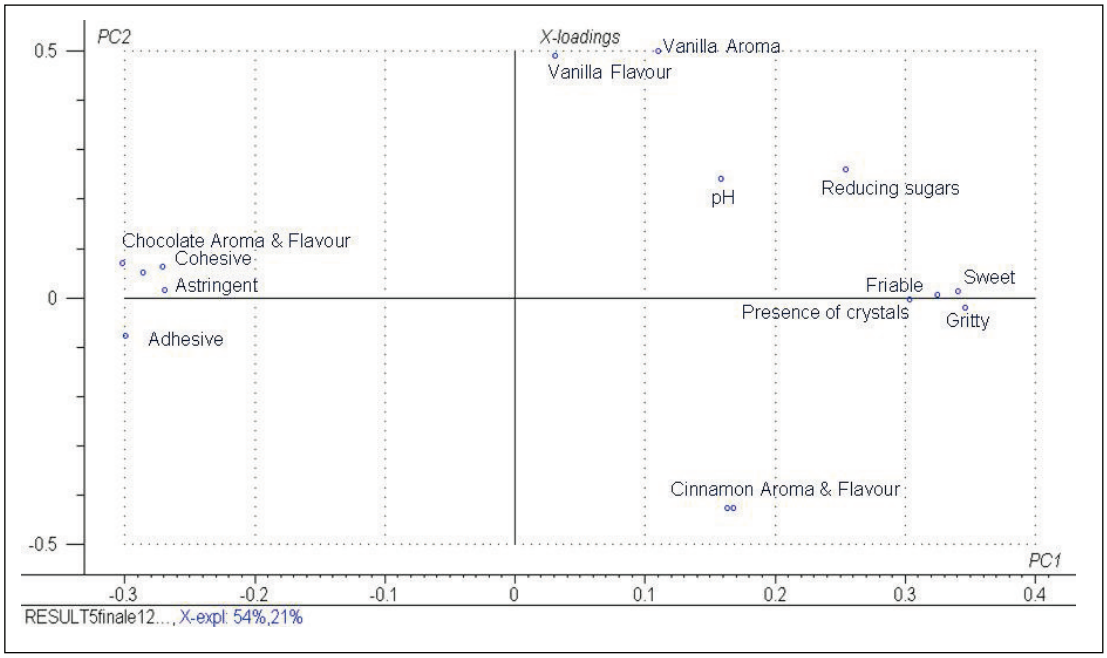

Fig. 2 - Loading plot of chocolate samples.

Figure 2 represents the plot of the sensory and physico-chemical parameters in the plane defined by the first two components.

The commercial samples (N and D) on the left of the first PC in Fig. 1 are negatively correlated to the Presence of Crystal, Friable, Gritty and Sweet, and positively correlated to Chocolate Aroma and Flavour, Cohesive and Astringent. The results from PCA show that the sensory profile of the chocolate of Modica is very different from that of the other samples. In general, the second dimension makes the difference between the chocolate of Modica and commercial products.

CONCLUSIONS

The results obtained in this research show the peculiar sensory profile of the chocolate of Modica, a fact that differentiates it from the commercial dark chocolate, and principally the chocolate of Modica's attributes of appearance (Presence of crystals), taste (Sweet), and texture (Gritty), that are a result of its production technology. Despite its diversity, the chocolate of Modica did not lose two sensory attributes that are typical characteristics of chocolate: melting and cocoa flavour.

If aroma makes the difference between the cinnamon and vanilla references, it is not clear why some attributes (Colour uniformity, Bright, Sour, Astringency, and Friable) of the cinnamon samples are not present in the sensory profile of vanilla samples. This result underlines the scarce homogeneity among the samples examined. In fact, each producer of the Association has "interpreted" the original recipe, varying the ingredients in their quantities and modifying some phases of the workmanship to shorten the production process. Therefore a follow up study is necessary to set a range of chemico-physical and sensory parameters to conform and standardize the production, so as to achieve the identification with the PGI brand. In fact, cacao and its products are still developing and there are some avant-gardists with strangest tastes who like orange, chilli, cinnamon, ginger, and even absinthe flavoured chocolate. This study made it possible to sort out the sensory dimensions on an ancient chocolate helping to get relevant and useful information to guide product development. It is nevertheless a fact that the industry and marketing must better understand the consumer sensory development in order to satisfy his needs.

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