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Original Article

Physicochemical and sensory features of wines produced at the "Serrana" region of Espírito Santo, Brazil

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Abstract: This study aimed to evaluate whether non-*Vitis vinifera* wines produced at the "Serrana" (mountainous) region of the Espírito Santo state (Brazil) meet the standards of identity and quality for marketing in Brazil, and to analyze the sensory profile of these drinks from a poorly explored region. We analyzed a total of 48 samples of non-*Vitis vinifera* wine from 19 wineries at the region, prepared exclusively with American and/or hybrid grapes. We carried out analytical determinations of density, alcohol content, total acidity, volatile acidity, total sugars, alcohol in weight/reduced dry extract, ashes, sulphates, chlorides, sulphur dioxide and methanol, using official methodologies. Sensory analyses were conducted by seven trained evaluators, through an adapted descriptive method. We used a structured five-point scale to evaluate the intensity of the descriptors. The results indicate that 60% of the samples studied did not met the standards established by the legislation, and consequently could not be marketed. Regarding sensory analysis, one of the highlights is the visual aspect of intensity, violet hue and the total intensity of the samples. Moreover, it was possible to make comparisons between the results of physicochemical and sensory analyses such as the high levels of volatile acidity and the score for undesirable taste, the values of methanol with violet hues and the herbaceous flavor.

Keywords: Wine, physicochemical Analysis, sensory Analysis.

Introduction

According to the Brazilian normative instruction nº 49/2011, any addition of oenological products to wine with the purpose to improve it or to preserve physicochemical or sensory properties, are regulated by the determination of lawful oenological practices [1]. Toxicological criteria of some chemical substances present in wine must be observed in order to ensure consumers' health protection [2]. The brazilian law defines wine as the drink obtained by alcoholic fermentation of the must of fresh, healthy and mature grapes, whose denomination is exclusive of this raw material [3].

For marketing wines, identity and quality standards (PIQ) required by the Brazilian Ministry of Agriculture, Livestock and Food Supply (MAPA) must be followed [4, 5]. The study of the chemical composition of wines supports evaluating its components, in order to provide evidence regarding stability and quality [6].

Wines may result in different characteristics depending on the grape used in its manufacturing and the region from where they come from. In addition, the final alcohol concentration, the conditions to which they are subjected and the chemical additions during fermentation generate varied end products [7].

Thus, the harmony among chemical components and sensorial characteristics is trivial to characterize the quality of wines. Following this statement, regardless of category or style, wines are required to be free of defects [8].

In recent years, some studies have been conducted to identify the physicochemical and sensory characteristics of non-*Vitis vinifera* wines of different Brazilian regions [9-12]. However, the wines produced at the state of Espírito Santo have not been included in this scenario so far, as they have not been registered at the MAPA, as identified in 2010; therefore, no statistical data is available for this branch [13].

A research conducted by the Brazilian Institute of Wines (IBRAVIN) indicated that the Brazilian consumers consider price or the cost-benefit ratio for purchasing decisions , being this the decision-making factor for the acquisition of wines, and secondly, the flavor, being sweetness, acidity and staining the factors of greatest impact [14]. Furthermore, consumers still shows some preference for colonial type products and preference for sensory aroma notes associated with the aroma and flavor of the grape and grape juice [11, 15, 16]. Such circumstances, associated with the popularization of this drink among young people promotes the non-*Vitis vinifera* wine, which represent more than 80% of the total volume of wine produced in Brazil [17, 14].

In this perspective, the Serrana region of Espírito Santo (ES) was classified in 2014 as a grape production area intended for industrialization [3]. This region is marked by artisanal, homely and familiar manufacturing of non-*Vitis vinifera* wine, at Italian colonization areas, which are close to the metropolitan area of the capital of the state (city of Vitória), and for this reason, on tourist development and wines and grapes as attractions, as well as their selling price.

In order to investigate this reality, regarding the scenery of brazilian viticulture in 2014, the ES state presents a traditional production, although of small scale and lacking data from the Brazilian Institute of Geography and Statistics (IBGE) [17]. Given the relevance of the such data and due to the absence of studies evaluating the scenario and the reality of the role of the ES state in this chain, this work aimed to analyze the physicochemical and sensory characteristics of the wines produced at the Serrana region, by means of the descriptive adapted method, according to Brazilian Agricultural Research Agency (Embrapa) Grape and Wine sensory analysis sheet, correlate the results and verify the sufficiency of the physical and chemical parameters to the standards established by the brazilian law, according to official methodologies from MAPA and from the International Organization of Vine and Wine (OIV) [13].

Material and Methods

Samples

We analyzed a total of 48 samples from 19 wineries at the Serrana region of ES, at the municipalities of Alfredo Chaves, Santa Teresa, Marechal Floriano, Vargem Alta e Venda Nova do Imigrante. The samples were collected directly from the farms that were identified by local Agriculture departments and entities including Embrapa and Brazilian Service to Support Micro and Small Enterprises (Sebrae) as a place where there is production of non-*Vitis vinifera* wine. The samples were provided in duplicate in accordance with the line of production of each establishment, in 750 mL properly labeled bottles, comprising crops between 2010 and 2016.

Physicochemical analyses

The wines were analyzed in duplicate by the Laboratory of Drinks of Vegetable Origin from Espírito Santo (LABEVES), which is integrated to the Institute of Technology of the Federal University of Espírito Santo (ITUFES/UFES). This laboratory is officially accredited by MAPA to perform physicochemical analyses of wines, through standardized methods according to the operating manual of beverages and vinegar, described at the Brazilian Normative Instruction 24/2005 and the International Wine Organization manual [18-20]. LABEVES is also accredited by the General Coordination of Accreditation/National Institute of Metrology, Quality and Technology (CGCRE/INMETRO), following the requirements established for testing and calibration laboratories (ABNT NBR ISO/IEC 17025:200).

Wines were analyzed in duplicate using classical analytical methods for density, alcohol content, total and volatile acidity (adjusted), total sugars, alcohol in weight/reduced dry extract, ashes, sulphates, total chlorides, total sulphur dioxide and methanol, using the equipment and methodologies presented in Table 1.

Table 1-description of equipment and strategies employed for analytical determinations of wines.

Analytical determination	**Equipment (Manufacturer, Model, City, Country)**	**Method Reference**
Relative density at 20° C/20° C	Electronic densimeter (Gilbertini, SuperAlcomat; Novate Milanese, Italy). Limit of detection: 0.0347 g/100 ml; Limit of quantification: 0.1158 g/100 ml.	[19]
Alcoholic degree real (% vol to 20° C)	Electronic Distiller & derivatives (Gilbertini, Super DEE; Novate Milanese, Italy); Electronic densimeter (Gilbertini, SuperAlcomat; Novate Milanese, Italy). Limit of detection: 0.0347 g/100 ml; Limit of quantification: 0.1158 g/100 ml.	[19]
Total titratable acidity (mEq/L)	Magnetic stirrer (Fisaton, 753, São Paulo, Brazil). Automatic burette (Laborglas with Blue Ribbon with PTFE bottle and tap rubber PEAR-25 ml, 1/10, São Paulo, Brazil). pH meter (Tecnopon, 210 MPA, Piracicaba, Brazil).	[19]
Volatile acidity (mEq/L)	Magnetic stirrer (Fisaton, 753, São Paulo, Brazil). Automatic burette (Laborglas with Blue Ribbon with PTFE bottle and tap rubber PEAR-25 ml, 1/10, São Paulo, Brazil). Electronic Distiller & derivatives (Gilbertini, Super DEE, Novate Milanese, Italy).	[19]
Methanol (g/L)	Magnetic stirrer (Fisaton, 753, São Paulo, Brazil). Analytical balance (Tecnal, Marck 210A, Piracicaba, Brazil). Water bath (Quimis, Q334-18, São Paulo, Brazil). Spectrophotometer (UV version 3.0 Software Win Varian, Cary 50, Brazil).	[19]
Total sugars (g/L)	Heating plate (Quimis, Q313F11, São Paulo, Brazil). Water bath with internal turmoil with temperature controller (New Ethics, 500-4 d, São Paulo, Brazil). Tecnopon pH meter, 210 MPA, Piracicaba, Brazil). Automatic burette (Laborglas with Blue Ribbon with PTFE bottle and tap rubber PEAR-25 ml 1/10, Sao Paulo, Brazil).	[19]
Alcohol in weight/reduced dry extract *	Not applicable.	[19]
Sulfates (g/L)	Water bath (Quimis, Q334-18, São Paulo, Brazil).	[19]
Total chlorides (g/L)	Magnetic stirrer (Fisaton, 753, São Paulo, Brazil). Automatic burette (Vidrolabor with two taps of PTFE and 1 Liter bottle, 10 mL, 1/50, São Paulo, Brazil). PH meter, millivoltmeter (Digimed, DM-2, São Paulo, Brazil). Electrode Ag/AgCl (Silver/silver chloride) with a saturated solution of potassium nitrate as electrolyte (Digimed, DMR-CG1, São Paulo, Brazil).	[19]
Ash content (g/L)	Crucibles (Chiaroti, 50 mL, São Paulo, Brazil). Water bath (Quimis, Q334-18, São Paulo, Brazil). Analytical balance (Tecnal, Marck 210A, Piracicaba, Brazil). Muffle furnace (Fornitex, 3239, São Paulo, Brazil).	[19]
Sulphur dioxide (g/L)	Magnetic stirrer (Fisaton, 753, São Paulo, Brazil). Oenological Distiller with steam generator coupled (Gilbertini, DEE, Novate Milanese, Italy).	[20]

* The relationship between alcohol/ reduced dry extract is obtained by calculation of value of alcohol weight for reduced dry extract content.

Sensory Analyses

The sensory analyses of the samples were conducted at the LABEVES/ITUFES/UFES by a group of seven trained referees, comprising six women and a man, aged between 28 and 51 years old. For these analyses, it was used an adapted descriptive method in which a structured questionnaire ranging from 0 to 5 points (0 = worst concept and 5 = best concept) allowed the assessment of visual, olfactory and taste attributes of the wines, following specific classification criteria. The team held preliminary sessions in which they were explained in detail the goals of the experiment and training sections were conducted for the best use of the descriptors of the sensory analysis provided by Embrapa Grape and Wine.

The analyses were conducted in weekly sessions of approximately 1 hour, for five samples in average, following the operating temperature for white and red wines (6 to 12 °C and 14 to 16 °C, respectively) and the use of ISO standard crystal glasses (ISO 3591:1977). The tests took place in room with white light source uniform and controlled home temperature (22ºc ± 1). During all the sessions, glasses of water were made available to the referees to clean the palate.

The ethical aspects of the sensory analysis were approved prior to the commencement of the study by the Ethics Committee from Federal University of Espírito Santo (CCS/UFES, code 1.673.398).

Data Analyses

Data were processed with Microsoft Excel 2013 version and presented in the form of simple frequency, mean, standard deviation, coefficient of variation, maximum, minimum and use of graphics. Sensory analyses served as complement to physicochemical analyses.

The interpretation of the results of the sensory analysis was performed based on the averages of the particulars of the evaluators and the results presented graphically with the aid of Microsoft Excel version 2013. Such approaches were chosen considering that the goal of this qualitative research was to identify samples that fit into the quality standards established by the Brazilian law, with no purpose on detecting differences amidst the samples.

Results and Discussion

Characterization of wines

We identified five samples of dry white wine (VBSE), five samples of smooth white wine (VBSU), three samples of semi-dry red wine (VTDS), 13 samples of smooth red wine (VTSU), and 22 samples of dry red wine (VTSE) amidst the 48 total samples. They were manufactured in a varietal fashion or with a blend of the following grapes: Bordô, Carmem, Cora, IAC 138-22 (maximum), Isabel, Isabel Precoce, Jacquez, Margot, Moscato Embrapa, Niágara and Violeta.

Physicochemical analyses

When considering the average values, the analytical characterization of red wines (Table 1) evidenced that only the semi-dry wines were not in compliance to the brazilian legislation PIQ due to high levels of volatile acidity (27.07 mEq/L). However, there are samples with values that exceed the maximum and minimum limits (identified in the tables in bold) to the parameters of volatile acidity, total acidity, alcoholic degree, total sugars and methanol in the three categories of wine.

We identified alcoholic grading higher than 14% in samples VTSE 11, 12, 15, 16 and 22, VTSU 3 and 5, and lower than 8.6% in sample VTSE 19. There are evidences of Brazilian non-*Vitis vinifera* red wines alcoholic grading below the minimum threshold determined by the law [12].

We detected volatile acidity above the maximum allowable limit in samples VTSE 6, 13 and 19 and VTSU 2, 9 and 11. Deviations in volatile acidity are suggestive of contamination of and poor sanitary quality of the production process [21]. Regarding total acidity, samples VTSE 13 and 20, and VTSU 6 and 8, presented values above 130 mEq/L. High levels of total acidity imbalance the wine and impairs preservation [12].

The value of total sugars in samples VTSE 16 (12.40 g/L) and VTSU 11 (11.6 g/L) indicate the need for correct classification of samples in the category of semi-dry wine, in which the sugar levels range from 4.1 - 25 g/L [3]. Brazilian legislation only stipulates a limit of total sugars (80 g/L) for wines produced with viniferous grapes, for this reason the average value of this analytical parameter in VTSU (106.38 g/L) is not a deviation as they are american grapes wines [3].

High total sugar values might be related to the process of chaptalization lacking adequate control, once all the wineries surveyed in this research perform this step in their production processes. The excess of chaptalization in order to correct the alcoholic grading of VTSU can be perceived in the alteration of the results of the alcohol in weight/reduced dry extract in samples VTSU 1 and 3, which presented values above the maximum allowed.

Regarding methanol levels, albeit it is expected that its concentration in red wines of the american group is larger, samples VTSE 7, 9, 10, 11 and 12, and VTSU 10, 11 and 13, presented values above the maximum allowable limit. This is a worrisome result as methanol exhibits toxicity when consumed [21]. The adopted winemaking system, the addition of pectic enzymes and the extraction procedure for must impact directly on the final concentration of methanol in wine [22].

Table 1A-results of the classical analysis of red wines from the Serrana region of Espírito Santo, Brazil.

Sample	Alcoholic grading (°GL at 20 °C)	Total acidity (mEq/L)	Volatile acidity (mEq/L)	Sulphur dioxide (g/L)	Sulfates (g/L)	Alcohol in weight/reduced dry extract	Ashes (g/L)	Total sugars (g/L)	Chlorides (g/L)	Methanol (g/L)	Relative density to 20 °C/20 °C
VTSE 1	12.57	124.3	15.9	0.01	< 1	3.6	2.6	1.8	0.03	0.11	0.9946
VTSE 2	11.68	117.3	11.4	0.03	< 1	3.9	2.6	3	0.04	0.25	0.9947
VTSE 3	12.76	82.5	8.5	0.04	< 1	3.7	3.3	2.8	0.05	0.22	0.9946
VTSE 4	11.29	84.5	9.9	0.04	< 1	3.3	3.3	2.2	0.08	0.25	0.9961
VTSE 5	11.02	89.5	9.9	0.05	< 1	3.2	3.1	2.4	0.11	0.24	0.9964
VTSE 6	11.2	89.5	**32.2**	0.05	< 1	3.8	2.8	2.8	0.04	0.24	0.9952
VTSE 7	10.9	105.3	15.4	0.02	< 1	2.6	2.3	3.2	0.05	**0.53**	0.9995
VTSE 8	12.6	94.4	8.9	0.01	< 1	3.5	2.8	2.2	0.04	0.28	0.9951
VTSE 9	11.8	89.5	10.9	0.07	< 1	3.5	2.4	2	0.04	**0.46**	0.9953
VTSE 10	10.37	90.1	13.5	0.07	< 1	3.2	2.3	3	0.04	**0.48**	0.997
VTSE 11	14.52	101.1	9.5	0.02	< 1	4.3	1.6	3.4	0.04	**0.42**	0.9928
VTSE 12	15.39	113.1	6.5	0.01	< 1	4.6	2.1	2.6	0.04	**0.43**	0.9913
VTSE 13	11.31	**143.2**	**32**	0.03	< 1	3.1	2.3	2.6	0.02	0.16	0.9972
VTSE 14	10.96	105.3	9.4	0.02	< 1	2.9	2.3	1.2	0.04	0.26	0.997
VTSE 15	**15.5**	94.5	10.9	0.18	< 1	4.6	2.6	2.2	0.02	0.22	0.9913
VTSE 16	**14.96**	124.3	11.4	0.15	< 1	3.7	2.4	**12.4**	0.03	0.14	0.9977
VTSE 17	12.32	128.3	9.9	0.03	< 1	3.8	1.9	2.8	0.02	0.13	0.9947
VTSE 18	11.67	106.4	7.5	0.01	< 1	4.2	1.7	1.8	0.03	0.1	0.9935
19 VTSE	**7.78**	98.4	**31.8**	0.04	< 1	2.7	2.2	3	0.03	0.32	0.9993
20 VTSE	12.69	**130.3**	17.4	0.06	< 1	3.6	2.6	4	0.04	0.33	0.9956
21 VTSE	13.28	127.3	8.5	0.09	< 1	3.6	2.6	2.6	0.02	0.15	0.9947
22 VTSE	**14.82**	83.5	9.9	0.01	< 1	4.4	2.3	2.6	0.03	0.29	0.9921
VTDS 1	12.05	**159.1**	**53.9**	0.01	< 1	2.2	2.5	5.8	0.04	0.24	1
VTDS 2	**16.51**	90.5	10.4	0.03	< 1	4.7	1.7	10.4	0.05	0.13	0.99
VTDS 3	13.42	101.4	16.9	0.06	< 1	3.9	2.3	6	0.05	0.26	1
VTSU 1	11.4	86.5	9.4	0.02	< 1	**6.1**	2.6	117	0.03	0.17	1.0354
VTSU 2	10.6	118.3	**31.5**	0.01	< 1	0.9	2.7	103	0.04	0.15	1.06

VTSU 3	**15.9**	87.5	15.4	0.01	< 1	**5.3**	2.6	73	0.03	0.25	1.0169

Table 1B-results of the classical analysis of red wines from the Serrana region of Espírito Santo, Brazil (continuation)

Sample	**Alcoholic grading (°GL at 20 °C)**	**Total acidity (mEq/L)**	**Volatile acidity (mEq/L)**	**Sulphur dioxide (g/L)**	**Sulfates (g/L)**	**Alcohol in weight/reduced dry extract**	**Ashes (g/L)**	**Total sugars (g/L)**	**Chlorides (g/L)**	**Methanol (g/L)**	**Relative density to 20 °C/20 °C**
VTSU 4	12.4	95.5	13.9	0.01	< 1	2.8	1.6	178	0.05	0.22	1.0633
VTSU 5	**14.4**	87.5	13.4	0.02	< 1	3.7	2.5	69	0.03	0.3	1.0198
VTSU 6	13.6	**157.1**	12.4	0.11	< 1	3.8	2.6	110	0.03	0.24	1.0355
VTSU 7	13	94.5	15.9	0.01	< 1	2.3	2.1	160	0.05	0.3	1.0596
VTSU 8	11.6	**139.2**	12.4	0.17	< 1	3.1	2.8	48.4	0.04	0.28	1.0145
VTSU 9	11.5	110.4	**30.7**	0.01	< 1	2	1.8	117	0.05	0.23	1.0472
VTSU 10	12.4	91.4	13.4	0.11	< 1	1	2.8	118	0.05	**0.5**	1.0283
VTSU 11	11	101.3	**24.6**	0.06	< 1	0.7	3.3	**11.6**	0.05	**0.4**	1.0408
VTSU 12	10.7	68	12.5	0.06	< 1	3.4	2.8	122	0.05	0.28	1.0421
VTSU 13	12.3	109.1	14.5	0.02	< 1	2.2	2.1	156	0.04	**0.39**	1.0588
Lim. (min./Max.)*	8.6-14.0	55.0-130.0	0-20.0	0-0.35	1	0-4.8	> 1.5	0-4.0[a]; 4.1–25[b]; >25.1[c]	0-0.20	< 0.35	-
Mean ± Sd† VTSE	12.34 ± 1.86	105.5 ± 17.87	13.69 ± 7.90	0.05 ± 0.04	< 1	3.63 ± 0.56	2.46 ± 0.44	3.03 ± 2.18	0.04 ± 0.02	0.27 ± 0.12	0.9953 ± 0.0022
CV (%) VTSE	15	17	58	94	-	16	18	72	51	46	0
Mean ± Sd‡ VTSU	12.36 ± 1.55	103.5 ± 23.81	16.92 ± 7.20	0.05 ± 0.05	< 1	2.87 ± 1.63	2.48 ± 0.47	106.38 ± 46.5	0.04 ± 0.01	0.29 ± 0.10	1.0402 ± 0.0171
CV (%) VTSU	13	23	43	109	-	57	19	44	22	34	2
Mean ± Sd§ VTDS	2.28 ± 13.99	117 ± 36.86	**27.07 ± 23.46**	0.03 ± 0.03	< 1	3.6 ± 1.28	2.17 ± 0.42	7.4 ± 2.6	0.05 ± 0.01	0.21 ± 0.07	0.9974 ± 00.53
CV (%) VTDS	16	32	87	75	-	35	19	35	12	33	1

VTSE, dry red wine; VTSU, smooth red wine; VTDS, semi-dry red wine; ºGL, Graus Lussac; Sd, standard deviation; CV, coefficient of variation; Lim. (Min./max.), Upper and lower limits. * Minimum and maximum limits according to legislation [3-5]; † Sd, standard deviation of twenty-two samples; ‡ Sd, standard deviation of thirteen samples. § Sd, standard deviation of three samples. [a]limit for smooth wine; [b]limit for semi-dry wine; [c]limit for dry wine.

Numbers in boldface are samples for which the results are not in agreement to the limits established by the law.

When considering only the averages for the analytical characterization of white wines (Table 2), only VTSE samples would not be in compliance to PIQ regarding the total sugar content; however, we also found deviations in alcoholic grading and total acidity. The alcoholic grading of samples VBSE 4 and 5 are above the maximum limit allowed by the law. The total acidity of sample VBSU 4 is above the upper limit of MAPA, and the values of total sugars in samples VBSE 2 and 3 would rate these samples in the category of semi-dry white wine.

The Decree Law No. 8198 of February 20th 2014 describes as an infringement the production, preparation, qualification, package, label, transport, export, import, have on deposit and market wines and grape and wine derivatives that are not in compliance with the standards of identity and quality established by laws 10970/2004 and 7678/1988 [3-5].

Among the wines analyzed (n = 48), 60% (29 samples) are not in compliance with the PIQ according to the current legislation in at least one of the following analytical parameters: total acidity, volatile acidity, total sugars, alcoholic grading, methanol levels and alcohol in weight/reduced dry extract, thus, they would be technically forbidden from being marketed due to these inadequacies. Regarding to the total sugar content, classifying them as semi-dry would solve this non-compliance. A research conducted in two wineries of the municipality of Santa Teresa, in the very state of ES, found full appropriateness to PIQ of dry red wines of Isabel variety [23]. Another study with brazilian non-*Vitis vinifera* wines from the south, southeast, northeast and midwest regions, found adequacy in only one out of 49 samples [24].

Table 2- Results of the analyses of the classic white wines of the Serrana region of Espírito Santo, Brazil.

Sample	Alcoholic degree (° GL to 20° C)	Total acidity (mEq/L)	Volatile acidity (mEq/L)	Sulphur dioxide (g/L)	Sulfates (g/L)	Alcohol in weight/reduced dry extract	Ashes (g/L)	Total sugars (g/L)	Chlorides (g/L)	Methanol (g/L)	Relative density at 20° C/20° C
VBSE 1	9.38	59.6	8.9	0.09	< 1	3.9	2.5	1.4	0.04	0.25	0.995
VBSE 2	9.25	86.4	12.9	0.05	< 1	3.1	2.7	**19.6**	0.03	0.2	1.004
VBSE 3	9.51	64.6	19.4	0.11	< 1	3.9	3.3	**9**	0.03	0.22	0.9979
VBSE 4	**16.25**	65	6	0.04	< 1	4.7	2.8	1.4	0.03	0.24	0.9903
VBSE 5	**16.46**	64.6	6	0.03	< 1	4.8	2.7	1.6	0.03	0.19	0.9901
VBSU 1	12.33	99.4	6.5	0.01	< 1	3.4	3.4	98	0.04	0.26	1.0323
VBSU 2	11.83	100.4	5	0.01	< 1	4	1.9	138	0.04	0.24	1.0464
VBSU 3	10.22	59	10.5	0.05	< 1	4.1	1.9	104	0.05	0.26	1.0337
VBSU 4	11.22	**138.1**	10	0.01	< 1	4.9	1.8	116	0.04	0.3	1.0364
VBSU 5	12.27	98.4	7	0.01	< 1	3.4	2	99	0.04	0.25	0.995
Lim. (min./Max.)*	8.6-14.0	55.0-130.0	0-20.0	0-0.35	1	0-6.5	> 1.3	0-4 .0[a] > 25.1[b]	0.0-0.20	< 0.35	-
Mean ± Sd† VTSU	11.57 ± 0.88	99.06 ± 27.98	7.8 ± 2.36	0.018 ± 0.02	< 1	3.96 ± 0.62	2.2 ± 0.67	111 ± 16.7	0.04 ± 0.0044	0.26 ± 0.02	1.0363 ± 0.0059
CV (%) VTSU	8	28	30	99	-	16	31	15	11	9	1
Mean ± Sd† VBSE	12.17 ± 3.82	68.04 ± 10.50	10.64 ± 5.66	0.06 ± 0.03	< 1	4.08 ± 0.69	2.8 ± 0.3	**6.6 ± 7.97**	0.03 ± 0.0044	0.22 ± 0.03	0.9954 ± 0.0058
CV (%) VBSE	31	15	53	54	-	17	11	121	14	12	1

VBSE, dry white wine; VBSE, smooth white wine; ºGL, Lussac Degrees; Sd, standard deviation; CV, coefficient of variation; Max, maximum; min, minimum. *Maximum and minimum Limit in accordance to the law [3-5]; † Sd five samples. [a] limit for smooth wine; [b] limit for dry wine.
Numbers in boldface are samples for which the results are not in agreement to the limits established by the law.

Sensory analysis

The sensory analysis of VTSE (Figure 1) shows the intensity of violet color and hue ass a remarkable visual feature. These were the descriptors that the minimum score (identified by the blue color) was higher than zero. Our data is consistent with the literature concerning Bordô wines produced in Brazil [25]. Comparing these results with physicochemical analyses, we detected samples with methanol levels above the maximum limit (VTSE 7, 10 and 11) that also showed higher scores of color intensity and violet hue (Table 3).

Other significant sensory characteristics to VTSE were the acidity, the pungency/potency, the sweetness, and undesirable taste and odor. American grapes acidity is higher than viniferous cultivars as a result of higher concentrations of organic acids in grape peels [26]. The acidity was also a sensory characteristic detected in other studies with wines of american grapes [25].

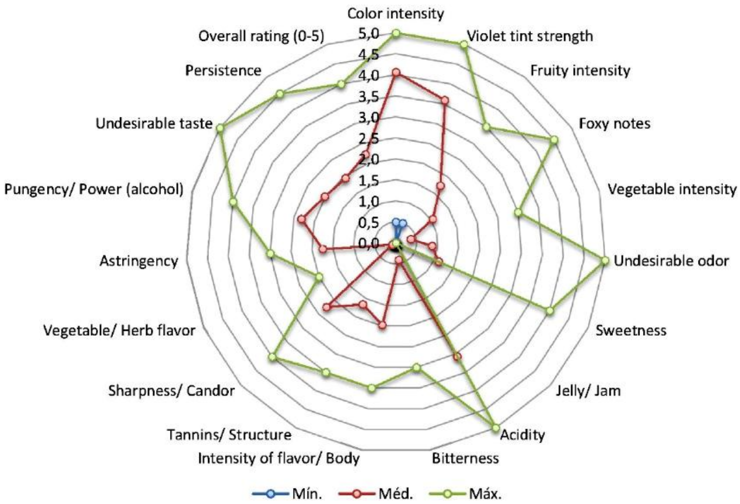

Figure 1 – Sensory profile of dry red wines (VTSE) of the Serrana region of Espírito Santo, Brazil.

Table 3A- Average scores set by the referees to red wines of the Serrana region of Espírito Santo, Brazil.

Sample	Color inten-sity	Violet tint stren-gth	Fruity inten-sity	Foxy notes	Vegetable intensity	Undesirable odor	Sweetness	Jelly /Jam	Acidity	Bitterness	Intensity of flavor/ Body	Tannins/ Structure	Sharpness /Candor	Vegetable /Herb flavor	Astrin-gency	Pungency / Power (alcohol)	Undesirable Taste	Persistence	Overall rating (0-5)
VTSU 1	3	4	1	0	0	0	4	0	3	0	1	2.5	4	0	1.5	3.5	0	2	3
VTSU 2	4	3	3.5	3	0	0	4	0	4	2	1	3	3	0	3	4	2	2	3
VTSU 3	2.5	2.5	0	0	0	5	3	0	4	0	1	2.5	0	0	0	4	5	0	0
VTSU 4	5	3	2	0	0	0	3	1	4	0	3.5	3.5	4	0	4	4	0	3	3
VTSU 5	3	5	2.5	0	0	0	3	0	4.5	0	3.5	3	4	0	4.5	4	0	2	4
VTSU 6	4	4	2.5	0	3	0	2.5	0	4.5	0	3	3.5	4	0	3	3	0	3	3.5
VTSU 7	3	2	4	2	0	0	5	0	4	0	3	3	3	0	3	4	0	2	3
VTSU 8	5	5	0	0	0	0	0	0	4.5	0	3	0	0	0	0	0	5	0	0
VTSU 9	3	3.5	3.5	0	0	2	4	0	3	0	3	3.5	3	0	3	3	0	2	3
VTSU 10	3	2	3	0	0	0	3.5	0	3	0	2	1	3	0	1	2	0	2	2
VTSU 11	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
VTSU 12	3	3	1.5	2	0	2	2.5	0	2.5	1.5	1.5	1.5	1.5	0	1	2	3.5	2.5	1.5
VTSU 13	5	5	2	3	0	0	3	0	3	0	3	2	3	0	2	3	0	3	3
VTSE 1	4	2	3.5	0	0	0	1	0	3	0	3.5	2.5	4	0	3	3	0	4	4
VTSE 2	4	2	3	0	0	0	1	0	4.5	0	2	2.5	1.5	0	2	3.5	0	2	2
VTSE 3	3	1.5	2	0	0	0	1	0	3	0	3	2.5	4	0	3	4	0	3	4
VTSE 4	5	5	1	0	0	0	2	0	4	0	2.5	1.5	2	0	2	3	0	1	2
VTSE 5	5	3	0	0	0	0	1	0	2	0	2	2	2	0	1	2	0	1	2
VTSE 6	3	2	3	0	0	0	1	0	3	0	3	3.5	4	0	2	3	0	3	4
VTSE 7	5	5	2	2	1	1	2	0	3	2	1.5	1.5	2.5	2	2	3	0.5	2	2.5
VTSE 8	4	4	2	0	3	0	1	0	4	0	2	2	2	0	2	2	0	2	3.5
VTSE 9	3	2	2.5	0	0	0	1	0	3	0	1.5	0	2	0	2	2	0	1	2.5
VTSE 10	5	5	2	4	0	0	0	0	3	2.5	2	1.5	3	0	1.5	2.5	1	2	1.5
VTSE 11	5	5	2	3	0	0	0	0	3	1.5	2	1.5	3	0	2	2	0	2	2
VTSE 12	0.5	0.5	0	0	0	5	0	0	0	0	0	0	0	0	0	0	5	0	0
VTSE 13	2	3	1.5	1.5	0	5	1	0	4	3	2	2	1	0	2	3	5	2	1.5
VTSE 14	4	4	0	0	0	0	1	0	4	0	1	0	2	0	0	2	5	1	1

VTSE 15	5	3	2.5	3	0	3	2	0	4	0	3	1.5	3	0	2	2	5	2	3
VTSE 16	5	5	3	1	0	0	4	0	4	0	3.5	3	3	0	3	3	0	3.5	4

Table 3B- Average scores set by the referees to red wines of the Serrana region of Espírito Santo, Brazil (continuation).

Sample	Color intensity	Violet tint strength	Fruity intensity	Foxy notes	Vegetable intensity	Undesirable odor	Sweetness	Jelly /Jam	Acidity	Bitterness	Intensity of flavor/ Body	Tannins/ Structure	Sharpness /Candor	Vegetable /Herb flavor	Astringency	Pungency / Power (alcohol)	Undesirable Taste	Persistence	Overall rating (0-5)
VTSE 17	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
VTSE 18	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
VTSE 19	5	5	1	4.5	0	5	1	0	4	0	1	0	2	0	0	2	5	4.5	1
VTSE 20	3	3	2	0	1	0	2.5	0	4	0	2	3.5	3	0	3	3	0	1	3
VTSE 21	4	4	2	0	3	0	1	0	5	0	3	2	2	0	3	3	4	3	2.5
VTSE 22	5	5	3	4	0	0	1	0	3	0	3	3.5	3.5	0	3	3	4	3	3
VTDS 1	3	4	0	0	0	5	2	0	4.5	0	1	0	1	0	0	4	5	4	1
VTDS 2	4	3	1	0	0	0	3	0	3	0	3	2.5	4	0	4	3.5	0	4	3
VTDS 3	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

VTSU, smooth red wine; VTSE, dry red wine; VTDS, semi-dry red wine.

It was possible to correlate the maximum sensory sweetness grading (Figure 1) with VTSE sample 16, which presented total sugars results of 12.4 g/L (Table 1), an amount much higher than the maximum limit established for dry wines, 4 g/L. The samples that extrapolated the limits established by the PIQ issues regarding volatile acidity and/or alcoholic grading (VTSE 12, 13, 15, 19 and 22) were those that presented higher scores for descriptors of undesirable taste and odor (Table 3).

The vegetable/herb flavor identified in sample VTSE 7 (Table 3) correlates with the physicochemical data (Table 1), which presented the highest value among the tested wines. The overly energetic grape crush results in excessive herbal taste and promotes the increased extraction of methanol from grape peels [27].

The most striking sensory characteristics of smooth wines (Figure 2) were the intensity of violet color and hue, acidity, and poignancy/potency. Comparing these results to physicochemical data, we found that samples with high content of methanol (VTSU 11 and 13) with the highest score for color intensity and violet tint; samples with higher values of total acidity (VTSU 6 and 8) presented a higher score of acidity; and samples with high alcoholic grading (VTSU 3 and 5) presented score high for poignancy/potency.

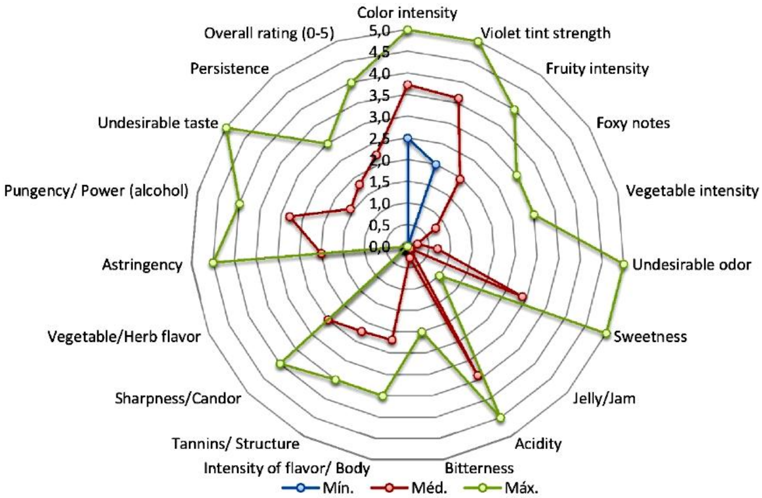

Figure 2 – Sensory profile of smooth red wines (VTSU) of the Serrana region of the Espírito Santo, Brazil.

We identified that samples with the highest score of undesirable taste (VTSU 3, 8 and 11) presented deviations regarding alcoholic grading, total acidity, volatile acidity or methanol levels; and samples with score zero for sweetness (VTSU 8 and 11) were those whose presented the lowest levels of total sugars. We noticed that eight out of the ten VTSU samples were not in compliance to PIQ, and they presented impairment of sensory quality regarding at least one of the following parameters: foxy notes, vegetable aroma intensity, undesired odor, lack of sweetness, bitterness, or undesirable taste.

It was observed high grading of color intensity and violet tint on the visual assessment of VTDS (Figure 3), indicating good color extraction of those wine samples. The descriptors undesirable taste and undesirable odor stand out in sample VTDS 1 (Table 3), that presented score 5 for both descriptors, for volatile acidity (53.90 mEq/L, Table 1). There was also a marked presence of acidity and pungency/potency.

The reuse of bottles increases the chances of contamination of the beverages, leading to the emergence of different tastes and aromas, what demands more control in the cleaning process [28]. While conducting the study, it was identified that a large part of the producers do reuse bottles in order to reduce production costs, what may have some contribution to our findings.

Regarding the average score in VBSE (Figure 4), the most outstanding descriptors were undesirable taste, acidity, olfactory intensity and total color intensity, with scores greater than 2 (Table 4). In the case of white wines, a greater color depth can be related to oxidation of the product, which is not a quality feature. In white wines, oxidation is responsible for darkening of the color of the wine and loss of aroma and fruity [29].

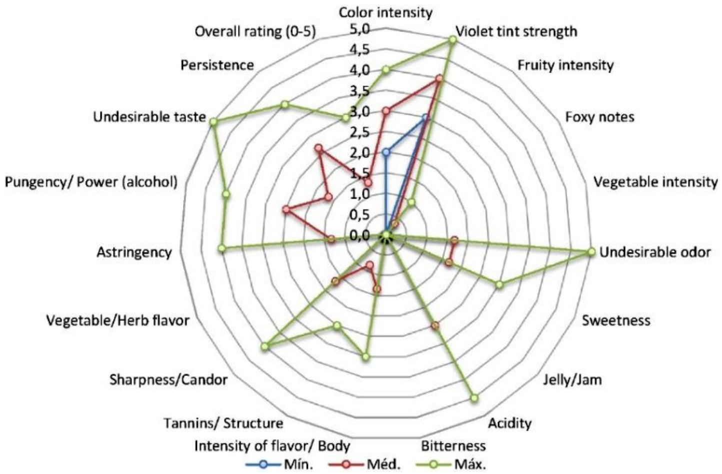

Figure 3- Sensory profile of semi-dry red wine (VTDS) of the Serrana region of the Espírito Santo, Brazil.

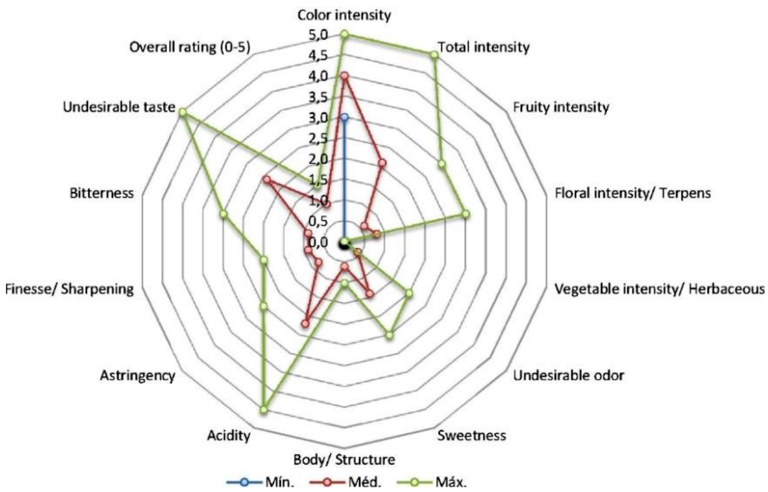

Figure 4 - Sensory profile of the dry white wines (VBSE) of the Serrana region of Espírito Santo, Brazil.

Table 4- Scores averages by the referees for the white wines of the Serrana region of Espírito Santo, Brazil.

Sample	Color intensity	Total intensity	Fruity intensity	Floral intensity*	Vegetable intensity†	Undesirable odor	Sweetness	Body/ Structure	Acidity	Astringency	Finesse/ Sharpening	Bitterness	Undesirable Taste	Overall rating (0-5)
VBSE 1	3.5	0	3	0	0	2	1	1	3	2.5	1	3	5	0
VBSE 2	5	1	0	0	0	0	0	0	0	0	0	0	0	1.5
VBSE 3	5	3	0	3	0	0	2	0	4.5	0	0	0	2	0.5
VBSE 4	3.5	1.5	0	1	0	0	1.5	1	1.5	1.5	1.5	0.5	0	1.5
VBSE 5	3	5	0	0	0	0	2.5	1	2	0	2	1	5	1.5
VBSU 1	3	4	3.5	0	0	0	3	3	3	3.5	4	0	0	3.5
VBSU 2	3	3	0	1.5	0	0	3	3	3	3	3.5	0	0	3.5
VBSU 3	4	3.5	3	0	0	0	1.5	1	1	1.5	0.5	0.5	0	2
VBSU 4	5	2.5	2	1.5	0	0	2	2	2.5	1.5	2	0	0	2.5
VBSU 5	4	4	0	2	0	0	3	2.5	4	3.5	4	0	0	3.5

VBSE, smooth white wine; VBSE, dry white wine. *Terpens. † Herbaceous.

Astringency and notes of undesirable taste and bitterness in VBSE may be related to the presence of stems under at the time of separation of rachis. The presence of stems under interferes negatively on the chemical composition of wines due to the low sugar levels and high acidity, as well as to promote bitter taste and sensation of astringency in the beverage [27]. The score 2.5 for sweetness descriptor in VBSE (Table 4) can be explained by the presence of VBSE samples 2 and 3 (Table 1), which presented total sugar levels above the maximum limits for dry wines.

Positive aspects

In VBSU we have not detected notes of undesirable taste and odor and of vegetable/herbal intensity (Figure 5). Bitterness reached the maximum sensory grading of 0.5 (Table 4), a positive aspect among the examined wines. VBSU wines were better evaluated, with general average grading of 3.0 whilst VBSE reached an average grading of 1.0.

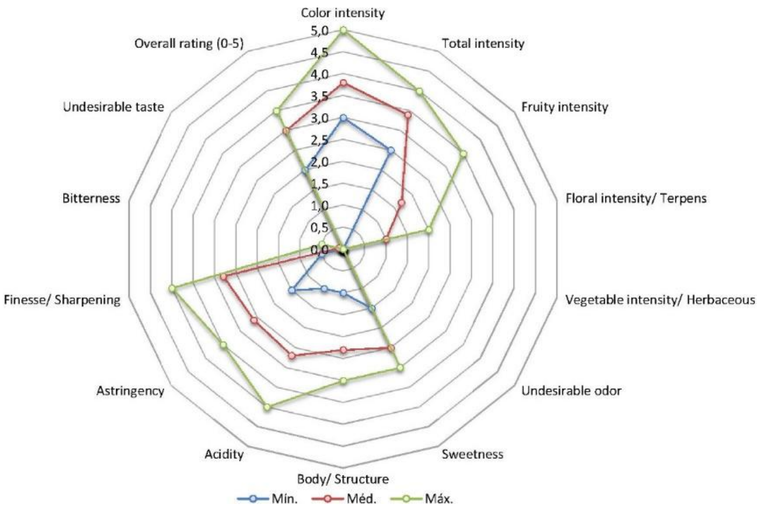

Figure 5 - Sensory profile of smooth white wines (VBSU) of the Serrana region of the Espírito Santo, Brazil.

Concerning the olfactory assessment of VBSU, total intensity featured an average outstanding score of 3.5. Floral, terpen and fruity notes were perceived. In the evaluation, astringency, acidity, finesse/sharpness showed an average score equal or higher than 2.5. The VBSE samples under study were prepared with the Niagara and Moscato Embrapa grapes varieties, while all the VBSU samples used just the Niagara grape in their composition. Such difference can be observed on the better distribution of descriptors showed on the results of VBSU (Figure 5) when compared to VBSE (Figure 4).

Conclusion

Given the physicochemical data, over 60% of wines presented results out of the quality standards set by the Brazilian law. Nevertheless, the deviations related to acidity, alcoholic grading, total sugars levels and alcohol in weight/reduced dry extract, could be adjusted through monitoring of the production process, with appropriate application of good oenological manufacturing practices and physicochemical analyses. The sensory profile of the studied wines varied deeply amidst the samples, what might be related to the great diversity of products provided spontaneously by wine-growers according to the work line. Thus, it is technically very difficult to conduct comparative analyses of products of different classes, vintages, and produced with varied proportions of grapes. It was possible, however, to correlate physicochemical and sensory findings. We here suggest that the disharmony between the physical components of the beverages interferes on sensory characteristics, and consequently, in quality. The present work opens doors for subsidizing, in a near future, works with the local producers with the aim of contributing to the improvement of the wine produced at the Serrana region of Espírito Santo.

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Contribution of the authors

Study of conception and design: L.K.R, S.D.L.A., A.C.N.C.
Acquisition of data:
Collection of samples: L.K.R, S.D.L.A, A.C.N.C., A.G.P.R.
Physicochemical analyses: E.S.S., A.C.N.C.
Sensory analyses: L.K.R, S.D.L.A, E.S.S., A.C.N.C.
Analysis and interpretation of data: L.K.R, S.D.L.A, A.C.N.C., E.S.S.
Provision of reagents/resources: A.G.P.R.
Manuscript Writing: L.K.R., A.C.N.C.
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