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POTENTIAL OF RUST-RESISTANT ARABICA COFFEE CULTIVARS FOR SPECIALTY COFFEE PRODUCTION

Tharyn REICHEL[1], Mário Lúcio Vilela DE RESENDE[1], Denis Henrique Silva NADALETI[2], Fábio de Oliveira SANTOS[1], Cesar Elias BOTELHO[2]

[1] Department of Plant Pathology, Universidade Federal de Lavras, Lavras, Minas Gerais, Brazil.
[2] Agência de Pesquisa Agropecuária de Minas Gerais (Epamig), Lavras, Minas Gerais, Brazil.

Corresponding author:
Denis Henrique Silva Nadaleti
denis.nadaleti@epamig.br

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Abstract
Rust is the main disease affecting *Coffea arabica*, the most economically important coffee species. The objective of this study was to analyze *C. arabica* cultivars with different levels of rust resistance, including bean size, raw bean appearance, final sensory scores (FSS), and aroma and taste nuances of the coffee cup. The experiment was designed in randomized blocks (RBD) with three replications and 20 treatments (cultivars), totaling 60 experimental plots. The rust-susceptible cultivars IPR 100, Rubi MG 1192, and Topázio MG 1190 were compared with 17 rust-resistant cultivars. Cultivars IPR 103, MGS Aranãs, and Saíra II presented the highest percentages of high sieves, highest scores of raw bean appearance, and low percentages of mocha-type beans. All cultivars had FSS above 82 and were classified as specialty coffees. The cultivars with the highest FSS (Arara and Catiguá MG2) showed a greater diversity of coffee cup aroma and flavor nuances. Rust-resistant Arabica coffee cultivars are promising for the physical quality of beans and have potential for the specialty coffee market.

Keywords: *Coffea arabica.* Cup quality. *Hemileia vastatrix*. Physical attributes. Sensorial attributes.

1. Introduction

Brazil is the largest producer of *Coffea arabica* L. (USDA 2020), which is the most economically important coffee species in the world. Concerning the world's Arabica coffee production, a volume of 105.32 million 60 kg bags was estimated in 2020 (ICO 2021). The great economic importance of Arabica coffee lies in its superior cup quality, characterized by smoother and richer flavors and aromas than *C. canephora*, the second most economically important species (Lima et al. 2020).

Cup quality combined with disease resistance is one of the main objectives of genetic breeding of coffee trees. The species *C. arabica* is the one most severely attacked by the fungus *Hemileia vastatrix*, the etiological agent of coffee leaf rust, symptoms of which range from defoliation to branch death (Avelino et al. 2015). Rust may limit coffee production in Brazil up to 50% depending on the genotype resistance level (Capucho et al. 2013). The most effective measure for rust disease control is the use of resistant cultivars (Zambolim 2016). This measure represents the most environmentally friendly and economical way to control rust because chemical control increases production costs, despite being efficient when properly applied (Shigueoka et al. 2014).

Coffee consumers are increasingly demanding high-quality coffee beans with unique characteristics (Lima et al. 2020). Therefore, cup quality is a determining factor for acceptance among consumers and the establishment of coffee prices in the market. The appreciation for specialty coffees, characterized by their greater cup quality, has grown. Sensory quality is commonly assessed by judges who use the protocol established by the Specialty Coffee Association (SCA) concerning the attributes of fragrance/aroma, uniformity, absence of defects, sweetness, flavor, acidity, body, aftertaste, balance, defects, and final score (Lingle 2011). Beyond cup quality, sensory analysis allows the identification of a series of aroma/flavor nuances, such as caramel, chocolate, fruity, citrus, and spices. This information is of great importance to coffee markets seeking to explore new niches and reach consumers with preferences for specific nuances.

Besides sensory quality, another factor that indicates the degree of acceptance established by the consumer market is physical quality, a characteristic that generates the security and reliability of the coffee to be consumed (Lingle 2011). In this context, the most important physical attributes are granulometry (bean size and shape) and the appearance of the processed raw beans. The physical and sensory properties of coffee beans are important for roasting industries that seek to buy coffee of desired quality and make blends (Toledo et al. 2016).

Brazil has a wide variety of producing regions and different coffee types that meet the market demand in terms of flavor and price (Barbosa et al. 2020). Therefore, to analyze the potential of *C. arabica* cultivars for specialty coffee production in association with rust resistance, this study aimed to assess 20 *C. arabica* cultivars with different levels of rust resistance in terms of physical attributes (granulometry and appearance of the processed raw beans) and cup quality (sensory attributes and aroma/flavor nuances).

2. Material and Methods

Experimental design, genetic material, and fruit processing

Field experiments were conducted in Lavras, Minas Gerais, Brazil (21°14’43” S latitude and 44°59’59” W longitude at 919 m altitude). The spacing was 3.80 m x 0.70 m between rows and plants, forming a stand of 4082 plants ha^{-1}. The experiment was designed in randomized blocks (RBD) with three replications and 20 treatments (cultivars), totaling 60 experimental plots composed of 10 plants each.

Twenty cultivars of *C. arabica* registered by different research institutions were evaluated in this study: 17 rust-resistant and three disease-susceptible cultivars that served as susceptibility controls (Table 1). The experiment was conducted according to the recommendations for the culture but with no application of fungicides to control rust.

The fruits were harvested at the cherry stage according to the maturation period of each cultivar (May–June 2020). Eventual impurities, unripe fruits, and low-density fruits were eliminated. Approximately 8 L of ripe fruits (cherry) were selected from each experimental plot, which were peeled and pulped through a biological mucilage layer for 24 h. The samples were washed by rubbing against the beans to remove any remaining mucilage.

The coffee beans were dried in screens suspended from the ground, forming a thin layer (7 liters/m²) in the first four days, followed by constant revolving until reaching 11% of water content. Subsequently, they were packed in "kraft" paper packages wrapped in plastic bags in a cold chamber at 16 °C for 30 days to uniformize the water content of the beans. After this period, the beans were processed, and all impurities and coffee bean fragments were removed and stored in a cold chamber for ten days until physical and sensory assessments.

Physical attributes

Samples of 300 g of processed raw beans, without extrinsic defects or coffee bean fragments, were analyzed in a set of sieves with circular sieves (19/64 to 12/64 for flat beans) and oblong sieves (13/64 to 08/ 64 for mocha beans) according to Normative Instruction No. 8 of MAPA (2003). The weights of the beans retained in sieves 16, 17, 18, and 19 (16 and above) and 13, 12, 11, 10, 09, and 08 (mocha) were added and converted to percentages.

Table 1. Cultivars of *C. arabica* with different levels of rust resistance assessed from field experiments.

Cultivars	Rust resistance	Institution
Acauã	Highly resistant	Fundação Procafé
Acauã Novo	Highly resistant	Fundação Procafé
Araponga MG 1	Highly resistant	EPAMIG
Arara	Highly resistant	Fundação Procafé
Catiguá MG 1	Highly resistant	EPAMIG
Catiguá MG 2	Highly resistant	EPAMIG
Catucaí Amarelo 2SL	Moderately resistant	Fundação Procafé
Clone 224	Highly resistant	Fundação Procafé
Clone 312	Highly resistant	Fundação Procafé
Guará	Moderately resistant	Fundação Procafé
IAPAR 59	Highly resistant	IAPAR
IPR 100	Susceptible	IAPAR
IPR 102	Moderately resistant	IAPAR
IPR 103	Moderately resistant	IAPAR
MGS Aranãs	Moderately resistant	EPAMIG
Pau-Brasil MG 1	Highly resistant	EPAMIG
Rubi MG 1192	Susceptible	EPAMIG
Saíra II	Moderately resistant	Fundação Procafé
Siriema AS1	Moderately resistant	Fundação Procafé
Topázio MG 1190	Susceptible	EPAMIG

EPAMIG: Agricultural Research Agency of Minas Gerais; IAPAR: Agronomic Institute of Paraná.

The appearance of the processed raw beans was assessed according to the methodology proposed by (Nadaleti et al. 2018). The samples were visually analyzed by three calibrated evaluators, who assigned scores on a scale from 1 to 5 points, where:1= beans with uneven appearance, discrepant color, and adhered endosperm; 2 = beans with uneven appearance, greenish color, and adhered endosperm; 3 = beans with medium appearance, greenish color, and slight presence of adhered endosperm; 4 = beans with uniform appearance, light bluish-green color, and slight presence of adhered endosperm; and 5 = beans with uniform appearance, intense bluish-green color, and no adhered endosperm.

Sensory analysis

For the sensory analysis, samples were standardized for beans retained in sieves 16 and above and without intrinsic and extrinsic defects. The samples were roasted to achieve a coloration from 55# to 65# on the Agtron scale for whole beans with a roasting time of eight–12 min according to the protocol proposed by SCA (Lingle 2011). The sensory analysis was performed in five cups per sample and by three Q-Grader certified judges, according to the protocol that consists of the following sensory attributes: fragrance/aroma, taste, aftertaste, acidity, body, balance, and overall, to which are awarded scores from 6 to 10 and, the attributes uniformity, sweetness, and clean cup that receive two scores per cup free of defects, uniform, and with minimal sweetness equivalent to a concentration of 0.5% w/v sucrose. The final sensory score (FSS) was calculated as the sum of the ten sensory attributes mentioned, considering special coffee with a final score equal to or greater than 80. Q-Grader judges also assessed the aroma/taste nuances of the samples. To compare the differences in the complexity of nuances according to FSS, the nuances of aroma and flavor present in the two cultivars that presented lower FSS and in the two cultivars that presented higher FSS were analyzed.

Statistical analysis

The data were subjected to the Shapiro–Wilk normality test and later to the analysis of variance. When significant differences were detected, the means were grouped using the Scott-Knott test ($p \leq 0.05$). Pearson's correlations between the sensory attributes, final sensory score (FSS), and complexity of nuances (sum of all nuances of each cultivar) were analyzed at a 5% significance level to understand the relationship between these attributes. To characterize the sensory profile of the assessed cultivars regarding the nuances of aroma/flavor, content analysis was performed according to a methodology adapted from Sobreira et al. (2015).

3. Results

The 20 cultivars of *C. arabica* differed significantly in all physical attributes analyzed in this study (Table 2). The coefficients of variation (CV) for the percentage of sieve 16/64 and above, mocha-type beans, and processed raw bean aspects were lower than 30%. For the flat beans retained in sieves 16 and above, the cultivars were divided into three groups. The highest values (between 66.0 and 77.3%) were verified for 11 cultivars (Arara, Catucaí Amarelo 2SL, Clone 224, Clone 312, Guará, IAPAR 59, IPR 102, IPR 103, MGS Aranãs, Rubi MG1192, and Saíra II), whereas the other cultivars were divided into the second and third groups, with mean values between 64.7 and 47.3%, respectively.

The cultivars Acauã, Acauã Novo, Catiguá MG1, Clone 224, Clone 312, and Pau-Brasil MG1 showed the highest values for the percentages of mocha-type beans (between 16.3 and 25.3%), whereas the other cultivars presented values between 8.7 and 15.0 % (Table 2). Regarding processed raw beans, the cultivars Saíra II, MGS Aranãs, Clone 312, and IPR 103 had the highest averages (between 3.7 and 4.7) compared to the other cultivars, which presented values between 2.6 and 3.6. Considering all physical attributes, cultivars IPR 103, MGS Aranãs, and Saíra II presented the highest values for sieves 16 and above and raw bean aspect and the lowest percentages of mocha-type beans (Table 2). In contrast, cultivars Acauã, Catiguá MG1, and Pau-Brasil MG1 presented the lowest values for 16 and above and bean aspect and the highest values for mocha.

Concerning the FSS, there was a CV equal to 1.25% (Table 2). The control cultivars IPR 100, Rubi MG1192, and Topázio MG1190 had FSS of 83.7, 83.1, and 83.0, respectively. These rust-susceptible cultivars did not differ statistically from the rust-resistant cultivars, with an average final score of 83.9. All cultivars analyzed in this study allowed the production of specialty coffees, as they presented scores above 80 points. Although the cultivars did not differ in FSS, they belonged to different classifications according to SCA (Lingle 2011). Coffees with scores between 80 and 84 are rated “very good”; coffees with higher scores between 85 and 89 are classified as “excellent,” as observed for cultivars Arara (85.2) and Catiguá MG2 (85.4).

Pearson's correlation analysis (r) was performed to verify the associations between the sensory attributes of aroma, flavor, acidity, body, aftertaste, balance, overall, FSS, and complexity of nuances (Table 3). Positive correlations were verified between sensory attributes, FSS, and complexity of nuances. Significant correlations were verified for all analyzed variables. The highest significant correlation between sensory attributes was verified for aroma and balance, flavor and acidity/body, acidity, and aftertaste/balance, which presented a correlation coefficient greater than 0.80. All sensory attributes were positively correlated with FSS ($r > 0.78$), with emphasis on flavor, balance, aftertaste, and acidity, which presented a coefficient of correlation of 0.96. The highest correlations between the complexity of nuances, sensory attributes, and FSS were verified for complexity, aroma, acidity, balance, and FSS ($r > 0.80$).

As the coffee of the cultivars was classified differently in terms of FSS by the SCA protocol, the aroma/flavor nuances of the cultivars may also differ according to this classification. To verify the differences in cup nuances between cultivars, the cultivars with the highest (Arara and Catiguá MG2) and lowest FSSs (IPR 102 and Topázio MG1190) were compared in this study. The Content Analysis of aroma/flavor nuances showed that cultivars with the highest FSSs presented greater nuance diversity than cultivars with the lowest scores (Figure 1). Cultivars Arara and Catiguá MG2 had 11 and 16 different nuances, respectively. In contrast, cultivars IPR 102 and Topázio MG1190 had four and five different nuances, respectively.

The cultivars with the highest FSSs had several nuances in common, such as caramel, honey, molasses, brown sugar, raw cane sugar, citrus, and fruity (Figure 1). In addition, the characteristic terms for each cultivar were observed. The terms assigned to Arara were yellow fruits, pineapple, and passion fruit, in contrast to Catiguá MG2, which was characterized by the terms red fruits, strawberry, winy, spices, lemon, and floral. The cultivars with the lowest FSSs were caramel, fruity, brown sugar, and chocolate (Figure 1). Except for chocolate, the aroma/flavor nuances verified in the cultivars with the lowest FSSs were also observed in the cultivars with the highest FSSs. The Cultivar Topázio MG1190 differed from IPR 102 only in terms of milk chocolate.

Table 2. Means for the percentage of sieve 16 and above (16 up), percentage of mocha-type beans (Mocha), processed raw bean aspect (Aspect), and final sensory score (FSS) of *C. arabica* L. cultivars with different levels of rust resistance.

Cultivars	16 up (%)	Mocha (%)	Aspect[1]	FSS[2]
Acauã	54.3 c	25.3 a	3.6 b	83.1 a
Acauã Novo	63.3 b	17.0 a	2.6 b	83.8 a
Araponga MG1	54.7 c	12.0 b	3.2 b	83.7 a
Arara	75.3 a	10.3 b	3.2 b	85.2 a
Catiguá MG1	50.3 c	23.3 a	2.8 b	83.5 a
Catiguá MG2	50.7 c	10.7 b	3.3 b	85.4 a
Catucaí Amarelo 2SL	75.7 a	11.7 b	3.1 b	83.7 a
Clone 224	71.0 a	16.3 a	3.1 b	83.5 a
Clone 312	69.0 a	20.3 a	4.1 a	84.5 a
Guará	76.3 a	8.70 b	3.1 b	84.3 a
IAPAR 59	75.0 a	9.30 b	3.1 b	84.1 a
IPR 100	64.7 b	14.0 b	3.1 b	83.7 a
IPR 102	66.0 a	13.3 b	2.9 b	82.3 a
IPR 103	72.3 a	10.0 b	3.7 a	83.3 a
MGS Aranãs	74.3 a	12.0 b	4.1 a	84.4 a
Pau-Brasil MG1	47.3 c	21.0 a	2.7 b	84.4 a
Rubi MG1192	77.3 a	11.0 b	2.9 b	83.1 a
Saíra II	72.7 a	11.0 b	4.7 a	84.6 a
Siriema AS1	60.7 b	15.0 b	3.2 b	83.8 a
Topázio MG1190	63.3 b	9.00 b	3.4 b	83.0 a
Overall mean	65.7	14.1	3.3	83.9
CV (%)	9.4	29.4	13.7	1.25

CV: coefficient of variation; [1] Scores range from 0 to 5; [2] Scores range from 0 to 100. Means followed by the same letter in the column do not differ by the Scott-Knott test at $p<0.05$.

Table 3. Pearson's correlation coefficient between sensory attributes and the cup's final sensory score (FSS) of 20 cultivars of *C. arabica*.

	Aroma	Flavor	Acidity	Body	Aftertaste	Balance	Overall	FSS
Flavor	0.64							
Acidity	0.78	0.83						
Body	0.53	0.81	0.77					
Aftertaste	0.56	0.78	0.88	0.76				
Balance	0.85	0.73	0.82	0.64	0.68			
Overall	0.76	0.67	0.75	0.46	0.64	0.66		
FSS	0.80	0.91	0.96	0.83	0.90	0.86	0.79	
Complexity	0.81	0.79	0.83	0.69	0.72	0.84	0.73	0.88

Values indicate significance at $p < 0.05$.

4. Discussion

The physical attributes (percentage of mocha beans and raw beans) of the 17 rust-resistant *C. arabica* cultivars were significantly equal or superior to those of the rust-susceptible control cultivars (IPR 100, Rubi MG1192, and Topázio MG1190). Except for Acauã, Acauã Novo, Catiguá MG1, Clone 224, Clone 312, and Pau-Brasil MG1, the resistant and susceptible cultivars had low percentages of mocha-type beans (between 8.7 and 15.0%). Most rust-resistant cultivars, especially Arara, Guará, and Saíra II, and the susceptible cultivar Rubi MG1192, had the highest percentages of sieves 16 and above (between 66.0 and 77.3%).

Unlike the flat bean, which has normal development, the mocha bean has an ovoid shape owing to the non-fertilization of one of the fruit's eggs (Pimenta et al. 2018). As coffee price is related to bean size, a high percentage of mocha-type beans implies a lower percentage of flat beans, resulting in lower market prices (Cheng et al. 2016). Thus, cultivars with flat beans, high sieves, and a low percentage of mocha beans are more promising for the coffee market. Moreover, higher percentages of larger beans ensure a greater yield of processed raw beans and batch uniformity, and consequently, more uniform roasting.

The uniformity of the beans in size and shape gives the coffee lots a better physical appearance, which is also influenced by the color and presence of the endosperm adhered to the processed raw beans (Nadaleti et al. 2018). In this study, Saíra II, MGS Aranãs, Clone 312, and IPR 103 presented the highest scores (above 3.7). These results agree with those found by Pereira et al. (2019), who also used moist processing and observed scores above 4.0 for the physical aspects of the beans of several cultivars, including MGS Aranãs. Considering all physical attributes analyzed in this study, the cultivars IPR 103, MGS Aranãs, and Saíra II are the most promising, as they present the highest values for percentage of flat beans retained in sieves 16 and above and raw bean aspect, and a lower percentage of mocha-type beans.

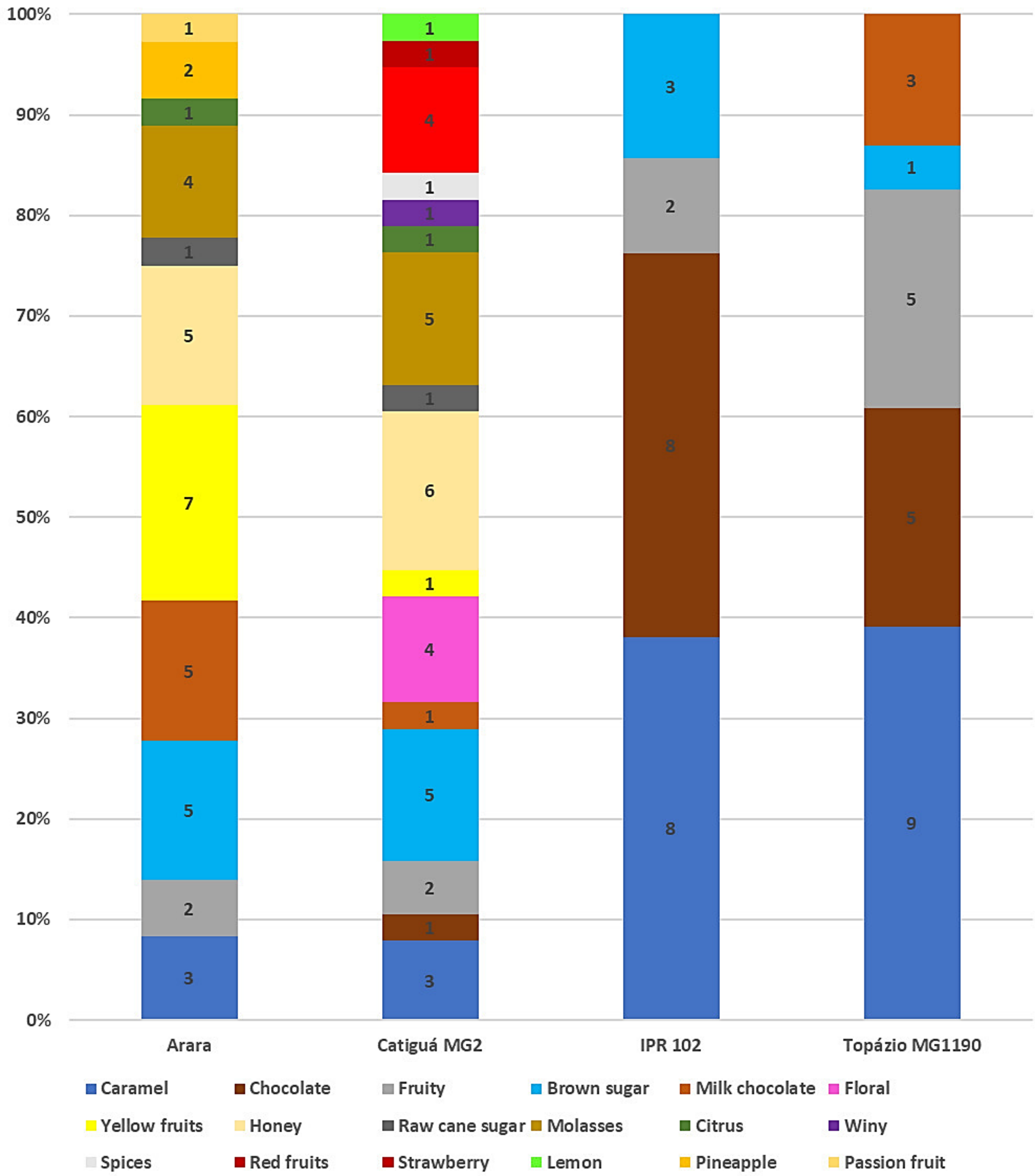

Figure 1. Content analysis of aroma/flavor nuances of cultivars with the highest (Arara and Catiguá MG2) and the lowest final sensory scores (IPR 102 and Topázio MG1190).

Besides the physical attributes, coffee sensory quality is another important factor to be considered during marketing when the objective is to add value to the product. Although several factors can influence cup quality, such as genetics, geographic location, climate, agricultural practices, and processing methods (Sunarharum et al. 2014), in the present study, there was low variability in FSS (1.25%), corroborating other studies (Silveira et al. 2016; Gamonal et al. 2017). This result indicates adequate experimental precision for this analysis based on the experience of judges trained according to the SCA protocol (Poltronieri and Rossi 2016; Velásquez et al. 2019).

All cultivars had FSS above 82 points and were classified as specialty coffees according to the SCA protocol (Lingle 2011). Specialty coffees have flawless beans, a clean cup, and pleasant aroma and taste(SCAA 2015). The highest cup scores were verified for the cultivars Arara (85.2) and Catiguá MG2 (85.4), which are classified as “excellent” within the category of specialty coffees (Lingle 2011). The control cultivars did not differ significantly from rust-resistant cultivars. Until recently, the cup quality of rust-resistant cultivars has been questioned because of the introgression of rust-resistant genes from *C. canephora* or *C. liberica* into *C. arabica*. This introgression could involve genes implicated in the genetic determinism of other traits, such as cup quality (Leroy et al. 2006). However, the results of this study demonstrate the potential of rust-resistant cultivars to produce specialty coffees.

Fassio et al. (2016) evaluated *C. arabica* cultivars with different levels of rust resistance and found that the cultivars Araponga MG1, Catiguá MG2, and Catiguá MG1 were the most suitable for producing specialty coffees in Minas Gerais. Carvalho et al. (2016) also highlighted the potential of the cultivars Araponga MG1 and Catiguá MG2 in Minas Gerais. Other studies have confirmed the genetic potential of sensory qualities of rust-resistant coffee genotypes in Minas Gerais (Sobreira et al. 2016; Barbosa et al. 2019; Pereira et al. 2019).

Sensory analysis is an important step in validating all processing stages before beverage production (Lingle 2011), such as post-harvest processing. This processing stage affects the coffee aroma and, consequently, cup quality (Toledo et al. 2016). Our results showed that the post-harvest practices applied to the samples were efficient for the expression of sensory quality. In addition to the genetic aspects of the cultivars and post-harvest processing, the region chosen for this experiment, Southern Minas Gerais, was considered adequate according to Chagas et al. (2005). These authors analyzed 22 counties in the southern region of Minas Gerais and concluded that this region has favorable soil and climate characteristics for producing superior quality coffee.

Sensory attributes were positively correlated with FSS in this study and other studies (Sobreira et al. 2015; Barbosa et al. 2020), indicating an association between these variables. These results indicate that higher scores for a sensory attribute imply a higher FSS. The sensory attributes of balance, flavor, aftertaste, and acidity had the highest correlation coefficients with FSS, corroborating the results of other studies (Kathurima et al. 2009; Carvalho et al. 2016; Pereira et al. 2017). Balance represents flavor, aftertaste, acidity, and body attributes present in equal proportions (Lingle and Menon 2017). The taste of good-quality coffee is characterized by a pleasant sensation and a balanced combination of flavor, body, and aroma in the absence of defects (Mori et al. 2003). Normally, there is a direct relationship between acidity increase and decrease in coffee quality, which was not verified in this study Oliveira et al. (2020). Our results indicated that acidity was a positive factor perceived by Q-Graders. Moist-processed coffees are generally more acidic, and such processing was used in the present work (Lima et al. 2008). This acidity may have contributed to the cup's liveliness, thereby increasing its sweet perception (Borém et al. 2016).

The study of nuances allows us to understand how the variety of aromas/flavors perceived in the samples affects the final sensory score. Content analysis of aroma/flavor nuances was used to characterize the sensory profile of the specialty coffees (Sobreira et al. 2015; Fassio et al. 2016; Freitas et al. 2020). According to this analysis, cultivars with the highest FSSs (Arara and Catiguá MG2) showed greater nuance diversity than those with the lowest scores (IPR 102 and Topázio MG1190). These results indicate that greater diversity of aromas/flavors implies higher cup scores. Pearson's correlation analysis between the sum of all nuances of each cultivar, sensory attributes, and FSS indicated that the complexity of nuances was associated with beverage quality. More specifically, the greater the complexity of nuances, the greater the notes of sensory attributes, especially aroma, acidity, and balance. These results demonstrate that greater nuance complexity results in higher FSS, in agreement with the content analysis of the aroma/flavor nuances.

Our results demonstrated that the rust-resistant cultivars Arara and Catiguá MG2 were associated with a greater diversity of nuances than the susceptible cultivar Topázio MG 1190. The flavor of specialty coffees is based on fruity, floral, and acidic scores (Bolka and Emire 2020), coinciding with the nuances verified for Arara and Catiguá MG2. The cultivar Arara, represented by yellow fruits, pineapple, and passion fruit nuances, differed from Catiguá MG2, characterized by red fruits, strawberry, winy, spices, lemon, and floral.

Knowledge of the nuances of specialty Arabica coffees is important for exporters, importers, and roasters to differentiate their quality and intensity from the final scores of commercial Arabica coffee, thus allowing them to serve different market niches (Sobreira et al. 2015; Lingle and Menon 2017). Coffee cup profiles with different nuances, especially flavors, reach a greater diversity of consumers who have different requirements for the beverage (Freitas et al. 2020).

In this study, we verified rust-resistant Arabica coffee cultivars that are promising for the physical quality of beans and have the potential for use in the specialty coffee market. As some of the cultivars analyzed are rust-resistant with superior cup quality, the implementation of these cultivars in crops can add value to the coffee produced by reducing production costs and environmental impacts (Barbosa et al. 2020).

5. Conclusions

The rust-resistant cultivars of Arabica coffee Saíra II, Guará, and Arara presented good cup quality, high percentages of high sieves, low percentages of mocha-type beans, and good appearance of the processed raw beans. Cultivars with the highest FSSs (Arara and Catiguá MG2) showed a greater diversity of aroma and flavor nuances in the coffee cup. The selection of cultivars to produce specialty coffees can be based on a coffee cup nuance analysis.

Authors' Contributions: REICHEL, T.: conception and design, acquisition of data, analysis and interpretation of data, drafting the article, critical review of important intellectual content; RESENDE, M.L.V.: conception and design, acquisition of data, analysis and interpretation of data, critical review of important intellectual content.; NADALETI, D.H.S.: conception and design, acquisition of data, analysis and interpretation of data, drafting the article, critical review of important intellectual content; OLIVEIRA, F.: acquisition of data, analysis and interpretation of data, BOTELHO, C.E.: conception and design, acquisition of data,analysis and interpretation of data, critical review of important intellectual content. All authors have read and approved the final version of the manuscript.

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