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Post-harvest of strawberry accessions in the South Minas Gerais

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ABSTRACT

There is great demand for new cultivars adapted for production in a national climate, which creates a certain dependence of national strawberry growers on imported cultivars. Thus, the objective of this work was to evaluate quality and morphological characteristics of fruits from strawberry genotypes. Strawberry accessions were provided by the Germplasm Bank of the Federal University of Lavras. The experiment was implemented in the Experimentation and Olericulture sector of the José do Rosário Vellano University (UNIFENAS). The experimental design used was in randomized blocks, with 12 treatments and 3 replications, totaling 36 experimental units. The 12 treatments consisted of seven genotypes and five commercial cultivars positioned in 29 slabs, in protected cultivation. The genotypes MFA12-443 and MCA12-89 stood out in terms of fruit size ($p<0.000$), presenting the highest values for length (41.06 mm), width (32.60 mm) and thickness (27.84 mm), while not differed from each other for these values. These genotypes are better suited for the fresh market, with quality characteristics that are more appreciated by consumers. All genotypes presented higher levels than 7ºBrix ($p= 0.000$) indicated for commercialization in the market. The tested accessions showed quality and aptitude for production in the southern region of Minas Gerais.

Keywords: *Fragaria x ananassa*, postharvest, soluble solids, breeding.

RESUMO

Pós-colheita de acessos de morangueiro no sul de Minas Gerais

Há grande demanda de novas cultivares adaptadas para a produção em clima nacional, o que cria certa dependência dos produtores de morango nacionais às cultivares importadas. Com isso, o objetivo do trabalho foi avaliar características de qualidade e morfológicas de frutas provenientes de genótipos de morangueiro. Os acessos de morangueiro foram cedidos pelo Banco de Germoplasma da Universidade Federal de Lavras. O experimento foi implantado no setor de Experimentação e de Olericultura da Universidade José do Rosário Vellano (UNIFENAS). O delineamento experimental utilizado foi em blocos casualizados, com 12 tratamentos e 3 repetições, totalizando 36 unidades experimentais. Os 12 tratamentos foram constituídos de sete genótipos e cinco cultivares comerciais posicionadas em 29 slabs, em cultivo protegido. Os genótipos MFA12-443 e MCA12-89 destacaram-se no tamanho de seus frutos ($p<0,000$), apresentando os maiores valores de comprimento (41,06 mm), largura (32,60 mm) e espessura (27,84 mm), enquanto não se diferenciaram entre si para estes valores. Estes genótipos apresentam melhor aptidão para o mercado *in natura*, com características de qualidade mais apreciadas pelos consumidores. Todos os genótipos apresentaram níveis maiores que 7ºBrix ($p= 0,000$) indicados para a comercialização no mercado. Os acessos testados apresentaram qualidade e aptidão para a produção na região do sul de Minas Gerais.

Palavras-chave: *Fragaria x ananassa*, pós-colheita, sólidos solúveis, melhoramento genético.

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In Brazil, strawberry production contributes significantly to the GDP (Gross Domestic Product), characterized as an activity with intense demand for labor. In Minas Gerais, strawberry is grown in most municipalities in the extreme south, with emphasis on Pouso Alegre and Estiva, the largest producers (Ceasa Minas, 2022). The south of Minas Gerais accounts for 95% of all state production, which corresponds to an annual production of approximately 85 thousand tons (Filgueira, 2013; IBGE, 2017), with the state being the largest producer of strawberries in Brazil.

However, the country has very few active programs for genetic improvement of the crop, due to lack of interest from private and public companies, creating a dependence on imported cultivars, which strongly impacts production costs, due to the intense use of inputs as fertilizers and pesticides, as well as the acquisition of seedlings (Galvão *et al*., 2014; Vieira *et al*., 2017; Souza *et al.*, 2019). From this angle, given the importance of this culture for the country, aiming to increase profitability, reducing production costs and dependence on imported genetic materials, it is essential to develop genotypes that are adapted to the climatic conditions of the growing regions (Zeist & Resende, 2019).

In this scenario, to ensure an efficient

recommendation, it is necessary to mitigate the effect of the genotype x environment interaction, searching for materials with better adaptability and greater predictability of behavior (Nick & Borém, 2016). However, it is noteworthy that most of the national strawberry production is still based mainly on imported cultivars, making the productive sector dependent on improvement programs from other countries, such as the United States and Spain. In addition, the strawberry genetic improvement aims to meet the demands of the consumer's market, with emphasis on the quality of the fruit (Souza *et al*., 2021).

Thus, the selection of genotypes that present good post-harvest quality and good phenotypic adaptation is extremely relevant for the development of the culture in the country. In view of the above, the objective of this work was to evaluate quality and morphological characteristics of fruits from strawberry genotypes in the city of Alfenas, Minas Gerais.

MATERIAL AND METHODS

Experimental design

The experiment was implemented in the Experimentation and Vegetable sector of the José do Rosário Vellano University (UNIFENAS), Alfenas, south Minas Gerais, (21^{0}25'45''S, 45^{0}56'50"W, 880 m altitude). The experimental design used was in randomized blocks, with 12 treatments and 3 replications, totaling 36 experimentals units. Each experimental unit consisted of 4 plants, totaling 144 plants. The 12 treatments consisted of seven accessions and five commercial cultivars (Table 1), positioned in 29 slabs. The strawberry accessions were provided by the Federal University of Lavras, as well as the commercial cultivars, which served as controls for comparison purposes in the experiment.

Planting and management

The seedlings were planted in April, where they were transplanted into slabs (33 cm x 1.60 m) in which 4 plants were placed in each. The slabs (plastic bags suitable for planting) were filled with Tropstrato HT substrate (Viva Verde company, Mogi Mirim-SP, Brazil), which contains pine bark, vermiculite, PG Mix 14.16.18, potassium nitrate, superphosphate plain and peat. For a greater standardization of the results, the strawberry was drip irrigated with an automatic digital hydrometer, keeping the substrate always at field capacity.

The matrices used in planting were obtained and previously multiplied by asexual propagation in order to form the UNIFENAS strawberry germplasm bank. From these matrices, new seedlings of each experimental genotype were produced in order to implement the experiment.

The experiment was carried out inside a greenhouse with a semi-detached arch protection structure covered by a 150 micron diffuser transparent agrofilm. An attack by fruit bugs (*Neopamera bilobata*), aphids (*Aphidoidea*) was identified, which were controlled with natural chemical applications before causing any damage to the production. The preventive management of pests and diseases was carried out with biweekly applications alternating the neem, garlic and tobacco solutions, according to production and application techniques illustrated by Jesus (2021).

Fertilization was performed according to data indicated in the culture literature (Ribeiro *et al*. 1999; Passos *et al*., 2015). Chemicals NPKForth Fruits (Forth Jardim, Cerquilho Velho-SP, Brazil) were used as fertilizers, in addition to foliar fertilization with micronutrients + Ca and Mg (calcium nitrate and magnesium sulfate), in order to meet all the demands of the crop.

Harvest, evaluations and statistical analyzes

Fruits were harvested in July, August, September and October 2021, in a staggered manner. The following evaluations were obtained: fruit size [length, width and thickness (digital caliper, mm)], amount of soluble solids (ºBrix, refractometer minimum brix measurement - maximum brix measurement: 0-90%), and the grades for shape, surface uniformity and color uniformity, according to UPOV (2012) indications. In each harvest, 1 to 5 strawberry samples were collected from each plant. In all, sixteen harvests were carried out, four in each productive month.

The data of ºBrix, length, width and thickness of the fruits were submitted to analysis of variance by the Sisvar software (Ferreira, 2014), and to the F test at 5%, and submitted to the Skott-Knott test at 5% of significance, aiming to differentiate the characteristics observed in each experimental genotype.

The data related to the morphological characteristics consisted of monthly average scores evaluated in 5 fruits in each harvest, in each plant. These data were evaluated by non-parametric statistics using the Kruskal-Wallis test, in order to identify possible differences between the plant morphology of each strawberry genotype. For non-parametric tests, the Real Statistics software (Zaoint, 2020) was used.

Table 1. Description of the 7 strawberry genotypes tested and their parents in the original hybridization. Alfenas, UNIFENAS, 2021.

Genotypes	Parental cultivars	
MDA-01	DOV	AROM
MDA-06	DOV	AROM
MCA12-94	CAM	AROM
MCA12-89	CAM	AROM
MFA12-443	FEST	AROM
MOGSC-468	OSO G	SCH
MDA12-23	DOV	AROM

AROM= Aromas, CAM= Camarosa, SCH= Sweet Charlie, DOV= Dover, FEST= Festival, OSO G= Oso Grande. Source: Galvão (2014).

To make possible the complete characterization and grouping of the genotypes, taking into account all evaluated production variables that gave significant differences, a hierarchical similarity dendrogram was prepared, according to the Euclidean distance of the samples, and the analysis of the principal components, using the Chemoface program, version 1.4 (Nunes *et al*., 2012). Multivariate analysis aims to study the behavior of many variables at the same time, reducing these variables through mathematical criteria, allowing to visualize in two-dimensional graphs only the most representative variable components of the data sets (Johnson & Wichern, 2002).

RESULTS AND DISCUSSION

The strawberry genotypes varied significantly for the attributes ºBrix (p= 0.000), length (p= 0.000), width (p= 0.000) and fruit thickness (p= 0.003) (Table 2).

The soluble solids content varies between cultivars and environmental conditions, being a characteristic of interest, especially for fruits sold *in natura*, as the consumer market prefers sweet fruits (Conti *et al*., 2002; Chitarra & Chitarra, 2005). Among all tested genotypes, the cultivars S. Andreas, Pircinque and Festival showed the highest values for ºBrix, on average 10.52º, not differing statistically from each other. The degree ºBrix is related to the content of soluble solids in the fruits. Higher values are desirable as they are more appreciated by consumers (Kader, 1991). The other evaluated genotypes did not differ from each other for this attribute, presenting an average of 7.80ºBrix, an average above the 7ºBrix indicated as a minimum reference for good acceptability in the market.

Strawberries with an acceptable flavor should have a minimum of 7.0°Brix of soluble solids and a maximum of 0.8% of titratable acidity (Kader, 1991). The content of soluble solids (SS) indicates the amount of all substances dissolved in the fruit pulp, consisting mainly of sugars, mainly sucrose, fructose and glucose (Chitarra & Chitarra, 2005). The evaluation of strawberry fruit quality takes into account aspects such as appearance (color, size, shape, absence of defects), firmness, flavor (soluble solids, titratable acidity), and nutritional value (Kader, 1991).

Considering the total size of the fruit, length, width and thickness are related. Regarding the length of the strawberries, among the genotypes tested, MCA12-94, MFA12-443 and MCA12-89 presented the highest values, on average 40.07 mm, not differing statistically among themselves and among the controls San Andreas, Pircinque, Albion and Aromas, which on average presented the value of 41.23 mm. Regarding width of the fruits,

Table 2. Soluble solids (ºBrix), length, width and thickness of commercial fruits (cm) of different strawberry genotypes. Alfenas, UNIFENAS, 2021.

Treatment	ºBrix	Fruit length (mm)	Fruit width (mm)	Fruit thickness (mm)
S. Andreas	11.47a	43.45a	28.28 c	25.22 b
Pircinque	10.19a	42.44a	27.28 c	24.75 b
Festival	9.90a	34.05 b	27.52 c	22.96 b
Albion	8.89 b	39.77a	29.28 c	26.09a
MDA-06	8.30 b	37.08 b	30.43 b	26.76a
MCA12-94	8.18 b	38.10a	28.95 c	26.41a
MOGSC12-468	7.80 b	33.98 b	27.67 c	24.46 b
Aromas	7.73 b	39.28a	30.05 b	26.16a
MDA12-23	7.54 b	34.01 b	28.10 c	24.92 b
MDA-01	7.49 b	33.58 b	26.75 c	23.12 b
MFA12-443	7.22 b	41.50a	32.50a	28.10a
MCA12-89	7.02 b	40.62a	32.69a	27.57a

Means followed by the same letters in the same column do not differ statistically at a level of 5% by the Scott-Knott test. Source: From the author (2021).

Table 3. Color uniformity, surface uniformity and fruit shape of different strawberry genotypes evaluated in Alfenas-MG. Alfenas, UNIFENAS, 2021.

Treatments	Color uniformity	Surface uniformity	Fruit shape
S. Andreas	Slightly uneven	uniform	Oval
Pircinque	Slightly uneven	uniform	Oval
Festival	uniform	Slightly uneven	Oval
Albion	Slightly uneven	uniform	Heart-shaped
MDA-06	uniform	uniform	Oval
MCA12-94	Slightly uneven	Slightly uneven	Oval
MOGSC-468	uniform	uniform	Oval
Aromas	Slightly uneven	Slightly uneven	Oval
MDA12-23	Slightly uneven	Slightly uneven	Oval
MDA-01	Slightly uneven	Slightly uneven	Oval
MFA12-443	Slightly uneven	Slightly uneven	Cylindrical
MCA12-89	Slightly uneven	Slightly uneven	Cylindrical
Kruskal-Wallis test (p values)	*0,035635	*0,011786	*0,041049

Reference of this characterization: UPOV (2012).

the genotypes MFA12-443 and MCA12-89 were statistically different from the others, and did not differ statistically from each other, with an average of 32.60 mm. Regarding thickness of the fruits, the genotypes MFA12-443, MCA12-89, MDA-06 and MCA12-94, together with the cultivars Aromas and Albion, stood out, presenting an average of 26.84 mm, and did not differ statistically from each other for this criterion.

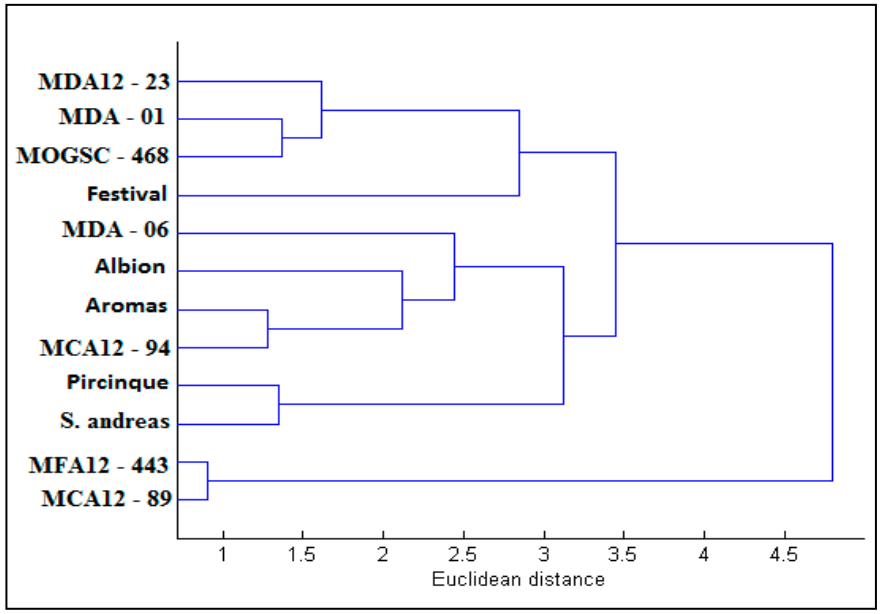

Figure 1. Dendrogram of similarity, with Euclidean distance, produced according to the observations of ºBrix, length, width, thickness, color uniformity, surface uniformity and fruit shape. Alfenas, UNIFENAS, 2021.

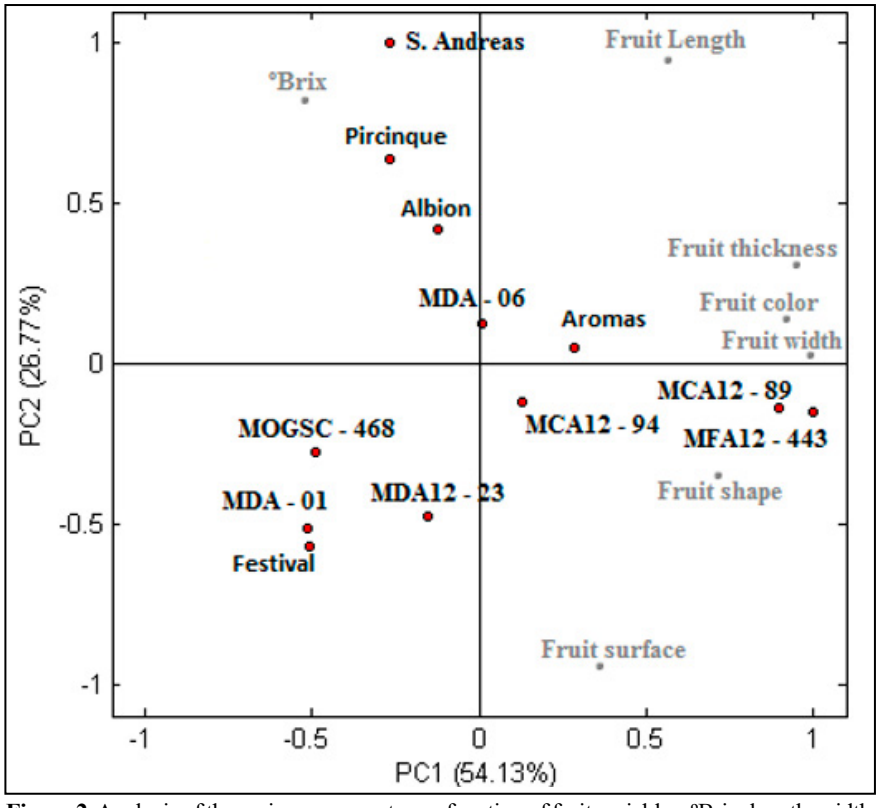

Figure 2. Analysis of the main components as a function of fruit variables: ºBrix, length, width, thickness, color uniformity, surface uniformity and fruit shape. Alfenas, UNIFENAS, 2021.

About total size of the fruit, relating length, width and thickness, the genotypes MFA12-443 and MCA12-89 stood out, presenting among all evaluated genotypes the highest values, not differing statistically from each other, being on average 41.06 mm long, 32.60 mm wide and 27.84 mm thick, and statistically differed from all other genotypes. Genotypes that produce larger fruits are more desirable for the fresh strawberry market, which are more appreciated by consumers. The size of the fruits is important not only to make the harvesting and packaging process faster, but also for the appreciation by the consumer market, resulting in greater gains for the producer (Conti *et al*., 2002). It is worth mentioning that a box of jataí bees (*Tetragonisca angustula*) was placed next to the experiment, aiming to favor the pollination of the flowers and improve the shape and uniformity of the fruits.

The cultivars San Andreas and Pircinque, despite having the highest ºBrix, presented the lowest values for width and thickness of strawberries. Cultivars that produce smaller fruits are more suitable for processing and industrialization. The results of the strawberry descriptions were presented in table 3.

In relation to color and surface uniformity of the fruits, the genotypes MDA-06 and MOGSC-468 had the best results (Note 1= uniform), as well as the commercial cultivar Festival taken as one of the controls. Fruits with more uniform characteristics are more suitable for the fresh consumption. The other genotypes presented a slightly uniform color (Note 2= slightly uniform), being more suitable for processing.

Uniform color and surface are important attributes in the selection of commercial materials as they are crucial quality characteristics in foods and key purchasing parameters, especially if the products are packaged, as it is the case of strawberries (Aday *et al*., 2013). For the commercialization of strawberries intended for fresh consumption, the external color is an important attraction

for the consumer, as it influences their expectations about the flavor and quality of the product (Moura *et al*., 2012).

Analyzing the shape of the fruits, most of them were oval, only the genotypes MCA12-89 and MCA12-443 were classified as cylindrical and the commercial cultivar Albion was classified as heart-shaped. The shape of the fruit, not being damaged by pests, diseases or mechanical action, will depend on the way in which the distribution of pollen between its stigmas occurs. Being irregular, there is production of deformed fruits, but when pollination occurs uniformly, the flowers will give rise to well-formed fruits (Malogodi-Braga, 2002).

The genotypes MDA12-23, MDA-01, MOGSC-468 and the cultivar Festival formed a similarity group, which presented intermediate characteristics for fruit size and lower for ºBrix, however, all presented the ºBrix content indicated for the market (Figures 1 and 2).These genotypes present intermediate aptitude for fresh consumption or for processing.

The genotypes MCA-89 and MFA12-443 represented a group of similarity and prominence in comparison to the other ones, as they presented the best results for size of the fruit (length, width and thickness), as well as the level of soluble solids higher than the minimum required in the market, also standing out in the uniformity of the color and surface of its fruits. These genotypes are better suited for fresh consumption, with quality characteristics that are more appreciated by consumers.

Similarity results are useful for the grouping of genotypes with similar characteristics, as well as for the confirmation of divergent genotypes, which are desirable considering future hybridizations and the continuity of the strawberry genetic improvement program in Alfenas-MG. The genotypes tested showed quality and aptitude for production in the southern region of Minas Gerais.

REFERENCES

ADAY, MS; BUYUKCAN, MB; CANER, C. 2013. Maintaining the quality of strawberries by combined effect of aqueous chlorine dioxide with modified atmosphere packaging. *Journal of Food Processing and Preservation* 37: 568-581.

CEASA MINAS. 2022. Informações de mercado – cultura do morango nas principais unidades do CEASA em Minas Gerais. Available at: <http://www.ceasaminas.com.br/informacoesmercadogeral.asp>. Accessed: April 25, 2022.

CHITARRA, MIF; CHITARRA, AB. 2005. Pós-colheita de frutos e hortaliças: fisiologia e manuseio. Lavras: ESALQ/FAEPE, 2. ed. 785p.

CONTI, JH; MINAMI, K; TAVARES, FCA. 2002. Produção e qualidade de frutos de morango em ensaios conduzidos em Atibaia e Piracicaba. *Horticultura Brasileira* 20: 10-17.

FERREIRA, DF. 2014. Sisvar: um guia dos seus procedimentos de comparações múltiplas Bootstrap. *Ciência e Agrotecnologia* 38: 109-112.

FILGUEIRA, FAR. 2013. Parte II Olericultura especial. Novo manual de olericultura: agrotecnologia moderna na produção e comercialização de hortaliças in: FILGUEIRA FAR (ed). 3rd ed. UFV, Viçosa.

GALVÃO, AG; RESENDE, LV; GUIMARAES, RM; FERRAZ, AKL; MORALES, RGF; MARODIN, JC; CATÃO, HCRM. 2014. Overcoming strawberry achene dormancy for improved seedling production in breeding programs. Idesia, Chile, v.32, n.4.

IBGE. Censo Agropecuário. 2017. Available at: <https://sidra.ibge.gov.br/tabela/6619#resultado>. Accessed May 15, 2021.

JESUS, GT. 2021. Caderno agroecológico: Produção de insumos para controle de insetos e doenças na horticultura. Repositório de Livros, e-books e outras produções do LaPPRuDes e Parceiros.

JOHNSON, RA; WICHERN, DW. 2002. Applied multivariate statistical analysis. Prentice hall Upper Saddle River, NJ.

KADER, AA. 1991. Quality and its maintenance in relation to postharvest physiology of Strawberry. In: Luby (ed). The strawberry into the 21st century, Timber Press, Portland, Oregon, EUA. p.145-152.

MALAGODI-BRAGA, KS. 2002. Estudo de agentes polinizadores em cultura de morango (Fragaria x ananassa Duchesne - Rosaceae). São Paulo: USP. 104p. (Ph.D thesis).

MOURA, SCSR; TAVARES, PER; GERMER, SPM; NISIDA, ALAC; ALVES, AB; KANAAN, AS. 2012. Degradation kinetics of anthocyanin of traditional and low-sugar blackberry jam. *Food and Bioprocess Technology* 5: 2488-2496.

NICK, C; BORÉM A. 2016. Melhoramento de hortaliças. 464p. Viçosa-MG: UFV.

NUNES, CA; FREITAS, MP; PINHEIRO, ACM; BASTOS, SC. 2012. Chemoface: a novel free user-friendly interface for chemometrics. *Journal of the Brazilian Chemical Society* 23: 2003-2010. ISSN 0103-5053.

PASSOS, FA; TRANI, PE; CARVALHO, RLC. 2015. Desempenho agronômico de genótipos de morangueiro. *Horticultura Brasileira* 33: 2015.

RIBEIRO, AC; GUIMARÃES, PTG; ALVAREZ, VVH. 1999. Recomendações para o uso de corretivos e fertilizantes em Minas Gerais. 5ª aproximação. Viçosa-MG.

SOUZA, DC; OSSANI, PC; RESENDE, LV; CIRILLO, MA; SILVA, LFL; XAVIER, JB. 2019. Variabilidade genética entre cultivares comerciais e híbridos experimentais de morangueiro com ênfase em análise de múltiplos fatores. *Magistra Cruz das Almas* 30: 48-59.

SOUZA, DC; OSSANI, PC; COSTA, AS; GUERRA, TS; ARAUJO, ALR; RESENDE, FV; RESENDE, LV. 2021. Selection of experimental strawberry clones for fruit appearance attributes. *Pesquisa Agropecuária Brasileira* (On line) 56: e02560.

UPOV - International Union for the Protection of New Varieties of Plants. 2012. Strawberry: Guidelines for the conduct of tests for distinctness, uniformity and stability. Geneva.

VIEIRA, SD; SOUZA, DC; MARTIN, IA; RIBEIRO, GHMR; REZENDE, LV; FERRAZ, AKL; GALVÃO, AG; RESENDE, JTV. 2017.Selection of experimental strawberry (*Fragaria* x *ananassa*) hybrids based on selection indices. *Genetics and Molecular Research* 16.

ZAOINT, C. 2019. Real statistics resource pack software (Release 7.6). Copyright (2013-2021). Available at: <https://www.real-statistics.com/free-download/real-statistics-resource-pack/>. Accessed December 12, 2021.

ZEIST, AR; RESENDE, JTV. 2019. Strawberry breeding in Brazil: current momentum and perspectives. *Horticultura Brasileira* 37: 7-16.