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Classification to Coefficient of Variation in Physical and Chemical Attributes of Oranges

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Abstract: A of the ways to evaluate data homogeneity in experiments is through the coefficient of variation (CV), however, in orange fruit evaluations, gaps are noted about the ranges that the variables must present due to their fluctuations as a function of factors genetic, climatic and agricultural. Thus, the present work aims to propose classifications of coefficient of variation for physicochemical attributes of orange fruits. For this purpose, CVs of 42 articles were used, considering soluble solids (SS), titratable acidity (TA), soluble solids and titratable acidity ratio (SS/TA), fruit length (FL), fruit diameter (FD), fruit mass (FM) and juice yield (JY), applying descriptive statistics and the Shapiro Wilk normality test. The limits proposed as low CV for the physical-chemical attributes of total soluble solids, titratable acidity, the ratio of total soluble solids and titratable acidity, fruit length, fruit diameter, fruit mass, and juice yield are respectively 2.11; 4.39; 4.46; 2.27; 2.59; 4.71 and 1.99% while the high CV range corresponds in the same sequence to 9.61;15.02;15.12;8.99;9.69;19.39;16.34%.

Keywords: Statistics analysis; experimental precision; variables; analytical methods; reliability; data analysis.

Adherence to the BJEDIS' scope: This work is based on the bibliographic survey and the use of descriptive statistics analysis and normality test to propose classifications of coefficient of variation for physicochemical attributes of orange fruits.

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1. INTRODUCTION

Used to estimate the precision of experiments, the coefficient of variation (CV) is a representative measure of the residual standard deviation, expressed as a percentage of the overall mean of the experiment (1). It allows the comparison between experiments without the need for equality in the number of repetitions (2).

According to the classification by Pimentel-Gomes (3), CV values below 10% are considered low, 10 to 20% are medium, 20 to 30% are high and above 30% are considered very high. The lower the value of the coefficient of variation, the greater the precision of an experiment (4). Low precision in experiments favors the occurrence of type I errors, making it difficult to find a significant difference between treatments, which impairs the correct indication of the best result (5).

To minimize errors, some factors must be taken into account in agricultural experiments, such as the number of repetitions, plot size, the experimental design used, the exposure conditions, and the culture used (6).

The classification of experimental precision is hampered by the lack of specific classification tables for the different experimental conditions (7). Because of this, there is a need to establish specific classifications of CV values, as they change according to the response variable under study and the culture considered (8).

The classification of CV values has already been established for some cultures and variables, such as morphological characteristics of the fruit of peppers of the genus Capsicum spp. (9), soybean yield and height (10) and seed production and the number of harvests of guarana (11).

For the orange crop, there is still a need to determine an ideal range of coefficient of variation for the various variables. Therefore, the present work aims to propose classifications of coefficient of variation for physicochemical attributes of orange fruits.

2. MATERIALS AND METHOD

The data used in the preparation of this study were acquired from articles and technical documents (given the precision of the treatments and optimization of reading and research time), without regional delimitation, production systems, or even cultivars delimiting publications in the range from 2005 to 2020. The search for works was carried out on the following electronic platforms: Springer, Elsevier, Google academic, Agricultural Research Data base (BDP@), Technological Information in Agriculture (Infoteca-e), and to obtain the maximum number of works in quality and quantity, The following keywords were applied: “orange fruit”, “quality fruit orange”, “yield orange”, “growth fruit orange”, “post-harvest orange”, physicochemical properties of orange and “physicomechanical properties of orange”.

A total of 42 articles that evaluated orange fruits were used, and they were conducted both in a completely randomized design and in a randomized block design. The research material was then organized in a Microsoft Excel® 2013 folder. For the construction and feeding of the worksheets, the data were initially subdivided into chemical attributes and physical attributes, with both the following information being common: variable, design, number of blocks (for cases of DBC), number of repetitions, coefficient of variation, year of publication and author reference for citation. Based on the highest frequency in the works, the variables selected for exploration in this work were: soluble solids (SS), titratable acidity (TA), soluble solids and titratable acidity ratio (SS/TA), fruit length (FL), the diameter of the fruit (FD), fruit mass (FM) and juice yield (JY).

From this, the coefficients of variation of the seven attributes of interest were subjected to descriptive statistical analysis in terms of frequency (n), maximum (Max) and minimum (Min), amplitude, mean (), median (MD), first and third quartiles (Q1 and Q3), interquartile range (IQR), pseudo-sigma (PS) and standard deviation (SD). In the R software (12) an analysis of the normal distribution was performed using the Shapiro-Wilk test, considering that in the data set, if the P-value is higher than the selected significance level (5%), the data have a normal distribution, otherwise, they do not meet this requirement.

One of the purposes of the normality test in this work is to guide the selection of the methodology for classifying the CV ranges, so that, if the normal distribution is met, the proposal elaborated by Garcia (13) is chosen, which defines

classes based on the mean of the CV plus or minus the standard deviation (Table 1) and if the data are not normal, the proposal by Costa et al. (6) which considers the median and pseudo-sigma as shown in table 2.

Table **1.** Classification limits the coefficients of variation according to the proposal by Garcia (13).

Classification	Interval
Short	CV≤ (CV médio – 1 S)
Medium	(CV médio -1S) < CV ≤ (CV médio + 1SD)
High	(CV médio + 1 S) < CV ≤ (CV médio + 2 SD)
Very high	CV > (CV médio + 2 S)

Table 2. Classification limits of the coefficients of variation according to the proposal by Costa et al. (6).

Classification	Interval
Short	CV≤ (MD – 1 PS)
Medium	(MD -1PS) < CV ≤ (MD+ 1PS)
High	(MD+ 1 PS) < CV ≤ (MD + 2 PS)
Very high	CV > (MD+ 2 PS)

3. RESULTS AND DISCUSSION

The variables that showed the highest frequency in articles involving chemical and physical attributes of orange fruits harvested in descending order are total soluble solids, titratable acidity, SS/TA ratio, juice yield, fruit mass, fruit length, and diameter of the fruit. Observing the behavior of the amplitude of the CV values, it is possible to see that the juice yield stands out, followed by the titratable acidity and the fruit mass (Table 3). The occurrence of an increase in the coefficient of variation related to these variables is directly correlated with the influence of external factors, such as plant characteristics in the field (14), temperature (15), treatment management and plant nutrition (16), water availability (17) since they are experiments conducted mostly in the field. However, it is important to consider that amplitude is the difference between the maximum and minimum values of a data set, which, because it does not weight the deviations of values from the mean, and therefore its application in an analysis of data variability must be careful (7).

The behavior in the amplitude directly reflects on the standard deviation of the CV values for the variable, since the variables that showed the greatest dispersion were also those that had the greatest standard deviation.

Table **3.** Descriptive statistics and Shapiro-Wilk normality test of coefficients of variation (CV%) in physicochemical attributes of orange fruits.

Variable	**SS**	**TA**	**SS/TA**	**FL**	**FD**	**FM**	**JY**
n	47	45	44	30	30	34	35
Max	12.26	31.30	30.50	9.68	11.30	27.34	59.29
Min	1.02	0.89	2.80	0.98	0.88	2.28	1.70
AMP	11.24	30.41	27.70	8.70	10.42	25.06	57.59
$\bar{X}$	4.88	8.94	9.11	4.90	5.13	10.60	9.69
Q2	4.61	7.93	8.02	4.51	4.96	9.61	6.77
Q1	2.93	5.54	5.62	3.00	3.36	6.30	3.54

Q3	6.30	10.33	10.41	6.02	6.55	12.91	10.00
IQR	3.38	4.79	4.80	3.02	3.20	6.61	6.46
PS	2.50	3.55	3.55	2.24	2.37	4.89	4.78
SD	2.59	6.63	5.38	2.62	2.75	6.17	11.88
Asymmetry	0.80	1.94	1.91	0.58	0.74	0.98	3.35
Kurtosis	0.11	3.85	5.09	-0.71	-0.32	0.65	11.71
SW	0.0128*	1.32E-06*	2.15E-05*	0.0263*	0.0343*	0.0166*	4.90E-09*

n: frequency; Max: maximum values; Min: minimum values; AMP: amplitude; $\overline{X}$: average; Q2: median; Q1: first quartile; Q3: third quartile; IQR: interquartile range; PS: pseudo-sigma; SD: standard deviation and SW: p-value of the Shapiro Wilk normality test.

It is also possible to notice that there is a certain proportionality between the values of the coefficients of variation of fruit mass and juice yield, even the latter presents extremely high values, and this relationship confirms results that point out that heavy fruits reflect in higher juice yield, and variations in these measures also depend on climatic factors, but above all on practices such as thinning and girdling performed or not in plant management during the experimental period (19).

The Shapiro-Wilk test presented significant CV data for all the analyzes studied in this work so that none of the variables presented normality in the data distribution, which allowed the classification of the CV value ranges (Table 4) proposed in the methodology by Costa et al. (6).

Table **4.** Classification ranges for the values of coefficients of variation (CV%) in the physicochemical attributes of orange fruits in different experiments.

	Classification range of CV % values			
	Short	Medium	High	Very high
	CV≤	< CV≤	< CV≤	CV>
SS	2.11	7.11	9.61	9.61
TA	4.39	11.48	15.02	15.02
RATIO	4.46	11.57	15.12	15.12
FL	2.27	6.75	8.99	8.99
FD	2.59	7.32	9.69	9.69
FM	4.71	14.50	19.39	19.39
JUICE YIELD	1.99	11.55	16.34	16.34

When evaluating the data expressed above, it is noted that in comparison with the ranges proposed by Pimentel-Gomes (3), all variables present an extremely rigorous and homogeneous behavior, with a lower CV limit below 5%, and maximum values below 20 %, with emphasis on the fruit mass variable that presented the highest value, which in the classification of Pimentel-Gomes (3) high is considered an average CV. However, it is notable the formation of two groups within the variables under study, a first group that groups the soluble solids, fruit length, and fruit diameter with low bands, and a second that includes titratable acidity, the ratio between soluble solids and titratable acidity, the mass of fruit and juice yield. Amaral et al. (2) also obtained lower values than those of Pimentel-Gomes (3) in the classification of coeficiente of variation for citrus characteristics.

The results of this work bring ao alert, to researchers who work with citrus fruits, for the quality of the data because it is a culture that involvess cloning and, in fact, greater experimental precision is expected, with lower values of the coefficients of variation.

CONCLUSIONS

The CV classification for the physical and chemical characteristics of oranges depends on the variable to be studied.

The limits proposed as low CV for the physical-chemical attributes of total soluble solids, titratable acidity, the ratio of total soluble solids and titratable acidity, fruit length, fruit diameter, fruit mass, and juice yield are respectively 2.11; 4.39; 4.46; 2.27; 2.59; 4.71 and 1.99% while the high CV range corresponds in the same sequence to 9.61;15.02;15.12;8.99;9.69;19.39;16.34%.

The experimental precision for the physical and chemical attributes of oranges can be measured based on the coefficient of variation, being an important tool in studies for the culture, attesting to the reliability of the experiment. Thus, lower values indicate greater precision of the data obtained.

CONFLICT OF INTEREST

There is no conflict of interest.

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Author statement

Valéria Pancieri Sallin: designed the study, and managed the writing of the manuscript, **Douglas Vicente do Carmo Lima:** managed the writing of the manuscript, Maria **Juliete Lucindo Rodrigues:** managed the writing of the manuscript, **Matheus Torezani Rossi:** managed the writing of the manuscript, **Vinicius de Souza Oliveira:** managed the writing of the manuscript, **Edilson Romais Schmildt:** designed the study, performed the statistical analysis, and managed the writing of the manuscript.

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