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ANIMAL PRODUCTION

Classification of the coefficient of variation to variables in beef cattle experiments

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ABSTRACT: *This research was conducted to propose a classification of the coefficient of variation (CV%) in many categories of variables of production and carcass of beef cattle experiments. The data was collected from theses and dissertations. We used the methods of classification considering mean and standard deviation, and considering median and pseudo-sigma. The two methods showed similar results so both can be used to classify CV%. We propose only three categories to rank CV%: low, medium and high.*
Key words: *animal science, animal experimentation, variability.*

Classificação do coeficiente de variação para variáveis de experimentos com gado de corte

RESUMO: *Neste trabalho propõe-se a classificação do coeficiente de variação (CV%) para diversas categorias de variáveis de produção e carcaça de experimentos com gado de corte. Os dados foram coletados de teses e dissertações. Foram empregados métodos de classificação considerando média e desvio padrão, e considerando mediana e pseudo-sigma. Os dois métodos mostraram resultados similares e ambos podem ser utilizados para classificar o CV%. Propõe-se, também, a classificação do CV% em apenas três categorias: baixo, médio e alto.*
Palavras-chave: *zootecnia, experimentação animal, variabilidade.*

The coefficient of variation (CV%) has been used by researchers to measure the variability of their experiments. To classify CV% has been the subject of interest in several areas of the Brazilian agricultural survey. The first proposal was founded by GOMES (1985) which has been of great help and provides the basis for the comparison of different studies. According to GOMES (1985), CV% is classified as low (CV%<10%), medium (CV% between 10% and 20%), high (CV% between 20% and 30%), very high (CV%>30%).

However, the classification of GOMES (1985) cannot be considered as valid for all studies. CLEMENT & MUNIZ (2002) studying the CV% in grasses, concluded that for different types of variables, the standard classification brought irregular interpretations. Thus, it is necessary to classify the CV% particularly for each variable or area of interest.

GARCIA (1989) proposed a classification of CV% in forest experiments by using mean and standard deviation. This methodology was also used later by several authors in their research (SCAPIM et al., 1995; AMARAL et al., 1997; JUDICE et al., 1999; CARVALHO et al., 2003). COSTA et al. (2002), considering aspects of the normal distribution of the CV% proposed the use of median and pseudo-sigma to classify CV%. Other authors have also adopted the methodology based on COSTA et al. (2002) for the classification of the coefficient of variation (FARIA FILHO et al., 2010; COUTO et al., 2013.).

The median and pseudo-sigma measures are robust for cases of non-normality. In cases where there are normality, according to COSTA et al. (2002), using mean and standard deviation or median and pseudo-sigma generated similar results. Considering the animal production area, some attempts of the

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coefficient of variation classification were made by JUDICE et al. (1999), for pigs, JUDICE et al. (2002), in rearing beef cattle, MOHALLEM et al. (2008), in broilers, and FARIA FILHO et al. (2010), in laying. There is no studies about production and carcass beef cattle. In this scenario, this study proposed classification for the coefficient of variation for beef cattle production and carcass variables.

Data was collected from theses and dissertations of the Post-Graduate Program in Animal Science of the Universidade Federal de Santa Maria (PPGZ / UFSM). Material was selected only when contemplating beef cattle area and contained information about general mean, standard deviation or coefficient of variation.

In total, there was reported 54 scientific papers (7 from theses and 47 from dissertations) from 1991 to 2014 of which were obtained: category of the variable analyzed; coefficient of variation; general mean; standard deviation. Categories analyzed were: weight gain (41 data that indicate the average daily gain of animals in experiments); intake (251 data that indicated the animal food intake and its components); conversion (43 feed conversion data); behavior (69 data related to animal behavior); empty body components (EBC) in kg (220 data related to empty body components measured in kilograms); empty body components (EBC) in percentage (233 data related to empty body components measured in percentage); ratio (45 data that analyze the ratio between body components); yield (43 data of cold or hot cattle body yield); break (51 data related to freezing and cooking of cattle body yield); fat (82 data of measurements of fat in carcass components); metric (174 data of height, length or area of cattle body components). At the end, we had a total of 1252 observations.

We calculated minimum, maximum, mean, standard deviation, median and first and third quartiles of the sampling coefficient of variation in the different categories. We performed the Shapiro-Wilk test (5% significance level) to verify the normality of the sampling distribution of CV%. Population coefficient of variation can be expressed by:

$CV\% = \frac{\sigma}{\mu} \cdot 100$ where σ is the population standard deviation and μ is the population general mean.

The first proposal of classification is based in GARCIA (1989) and follows: $CV\% \leq \bar{x}_{cv} - s_{cv}$ rated "low"; $\bar{x}_{cv} - s_{cv} < CV\% \leq \bar{x}_{cv} + s_{cv}$ rated "medium"; $CV\% > \bar{x}_{cv} + s_{cv}$ "rated high", where $\bar{x}_{cv}$ is the sampling mean of the coefficient of variation and S_{cv} is the sampling standard deviation of the coefficient of variation. This method is more appropriate to variables with normal distribution.

The second proposal was based in COSTA et al. (2002) and follows: $CV\% \leq Md_{cv} - PS_{CV}$ rated "low"; $Md_{cv} - PS_{cv} < CV\% \leq Md_{cv} + PS_{cv}$ rated "medium"; $CV\% > Md_{cv} + PS_{cv}$ rated "high", where Md_{cv} is the sampling median of the coefficient of variation and PS_{cv} is the pseudo-sigma of the coefficient of variation. The pseudo-sigma, by COSTA et al. (2002), follows: $PS = (Q_3 - Q_1)/1{,}35$, where Q_3 is the third quartile of sampling CV% and Q_1 is the first quartile of sampling CV%. This method is more robust to non-normality cases.

Ours proposals uses only three category of classification for the coefficient of variation (low, medium and high) that differs from previous proposals. This change comes out by the fact that CV% rated very high already means a high variability. Table 1 shows the descriptive analysis and results from the Shapiro-Wilk normality test. The minimum observed value of CV% was 0.02% in metric category and the maximum observed value was 35.91% in empty body components in kg (Table 1). In general, to all categories was observed similar values between mean and median. Shapiro-Wilk normality test showed that only weight gain, ratio, yield and break follows a normal distribution (Table 1).

In table 2 we have the classifications for CV% based on GARCIA (1989) and COSTA et al. (2002). Results are similar to both classification, even if, as can be seen in Table 1, most data showed no normality. We observed, in general, that the range of coefficient of variation was low, exception for yield. The highest limit to consider CV% low was 12% and the highest limit to consider CV% high was 23% (Table 2).

For example, weight gain was classified low CV% if less than 12% (or 11%), medium CV% if between 12% and 20%, and high CV% if bigger than 20% (Table 2). JUDICE et al. (2002) in beef cattle, using mean and standard deviation, classified CV% to weight gain as low if less than 10.25%, medium CV% if between 10.25% and 31.57%, high CV% if between 31.57% and 61.66% and very high if bigger than 61.66%. We can see similar values to classify low CV% in both proposals; however, the upper limit to rate CV% medium to high have differences. Besides that, JUDICE et al. (2002) considered using the very high rate of CV%, that differs from this study.

In the intake category of variables CV% the limit between low and medium rate was 4%, while for JUDICE et al. (2002) was 2.89%. The limit to classify CV% between medium and high was 10% while for JUDICE et al. (2002) was 7.63%. These values can be considered close, showing that for this category were reported similar results.

Table 1 - Minimum, mean, median, maximum, first quartile (Q_1), third quartile (Q_3), sampling size (n) and p-value of Shapiro-Wilk test (SW) for coefficient of variation (%).

Category	Minimum	Mean	Median	Maximum	Q_1	Q_3	n	SW
Weight gain	7.10	16.10	15.49	23.78	13.39	20.00	38	0.54
Intake	1.44	7.53	7.13	14.76	5.54	9.33	234	< 0.01
Conversion	3.38	12.13	12.37	20.82	8.06	16.49	41	0.01
Behavior	1.21	11.48	10.19	26.53	7.70	15.44	60	< 0.01
EBC in kg	1.42	14.56	12.33	35.91	7.10	19.79	202	< 0.01
EBC in %	0.61	7.99	6.60	23.15	3.08	11.15	212	< 0.01
Ratio	1.04	11.00	11.46	21.96	6.40	14.54	42	0.26
Yield	0.46	2.55	2.56	5.33	1.58	3.14	41	0.15
Break	0.11	14.19	14.38	28.73	10.24	18.96	45	0.15
Fat	2.07	12.99	12.56	28.66	7.31	18.05	78	0.04
Metric	0.02	5.77	4.95	14.32	3.28	7.84	141	< 0.01

In JUDICE et al. (1999), classifying CV% for pigs, we have the categories weight gain, feed conversion, feed intake and carcass yield. There were similar results to this study, especially for yield category, with the limit to classify between low and medium of 1.17% while this study was 1.40%. To the limit between medium and high, we have 3.12% for JUDICE et al. (1999) while for this study was 3.70%.

Considering the categories weight gain and intake, as noted in table 2, there were similar

Table 2 - Proposed classification of the coefficient of variation based on GARCIA (1989) and COSTA et al. (2002).

----------Proposal based on GARCIA (1989)----------			
Variable	Low	Medium	High
Weight gain	CV% ≤ 12%	12% < CV% ≤ 20%	CV% > 20%
Intake	CV% ≤ 4%	4% < CV% ≤ 10%	CV% > 10%
Conversion	CV% ≤ 7%	7% < CV% ≤ 17%	CV% > 17%
Behavior	CV% ≤ 5%	5% < CV% ≤ 18%	CV% > 18%
EBC in kg	CV% ≤ 6%	6% < CV% ≤ 23%	CV% > 23%
EBC in %	CV% ≤ 2%	2% < CV% ≤ 14%	CV% > 14%
Ratio	CV% ≤ 5%	5% < CV% ≤ 17%	CV% > 17%
Yield	CV% ≤ 1.4%	1.4% < CV% ≤ 3.7%	CV% > 3.7%
Break	CV% ≤ 6%	6% < CV% ≤ 22%	CV% > 22%
Fat	CV% ≤ 6%	6% < CV% ≤ 20%	CV% > 20%
Metric	CV% ≤ 2%	2% < CV% ≤ 9%	CV% > 9%
----------Proposal based on COSTA et al. (2002)----------			
Variable	Low	Medium	High
Weight gain	CV% ≤ 11%	11% < CV% ≤ 20%	CV% > 20%
Intake	CV% ≤ 4%	4% < CV% ≤ 10%	CV% > 10%
Conversion	CV% ≤ 6%	6% < CV% ≤ 19%	CV% > 19%
Behavior	CV% ≤ 4%	4% < CV% ≤ 16%	CV% > 16%
EBC in kg	CV% ≤ 3%	3% < CV% ≤ 22%	CV% > 22%
EBC in %	CV% ≤ 1%	1% < CV% ≤ 13%	CV% > 13%
Ratio	CV% ≤ 5%	5% < CV% ≤ 17%	CV% > 17%
Yield	CV% ≤ 1.4%	1.4% < CV% ≤ 3.7%	CV% > 3.7%
Break	CV% ≤ 8%	8% < CV% ≤ 21%	CV% > 21%
Fat	CV% ≤ 5%	5% < CV% ≤ 21%	CV% > 21%
Metric	CV% ≤ 2%	2% < CV% ≤ 8%	CV% > 8%

results to those obtained by JUDICE et al. (2002), and categories weight gain, intake, conversion and yield, the results were similar to those obtained by JUDICE et al. (1999).

FARIA FILHO et al. (2010), with layers and MOHALLEM et al. (2008), with broiler chickens, smaller amplitudes were observed for the coefficient of variation, which differs from the results obtained in this study. This is due to the fact that experiments with chickens have less variability.

In general, both range of the CV% as the boundaries between the categories of classification, in this study, are lower than those proposed by GOMES (1985), noting that this study did not consider categorizing CV% as very high. We recommend the use of this new intervals of classifications of CV% for experiments with beef cattle. In general, the intervals for cattle experiments have smaller range to those proposed in the classical literature.

The two methods used to classify the coefficient of variation generated similar results to variables of bovine production and carcass category. Any of them can be applied to classifications of CV%. The classification of the CV% in three categories (low, medium and high) is sufficient to measure the accuracy of experiments.

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