v. 2, n. 4, 2022

Journal of
Agricultural
Sciences
Research

ESTIMATES OF THE COEFFICIENT OF VARIATION IN EXPERIMENTS WITH FINISHING BEEF SHEEP IN CONFINEMENT

Jéssica Antonia Cardoso Mendes
Master in Animal Science by: Universidade Federal do Maranhão, Postgraduate Program in Animal Science, Chapadinha, Maranhão, Brazil
http://lattes.cnpq.br/5603659611947943

Karlyene Sousa da Rocha
Doctor in the program of: Universidade Federal do Pará, UFPA- Campus Castanhal, Pará-PA, Brazil
http://lattes.cnpq.br/6994465564529909

Sâmara Stainy Cardoso Sanches da Silva
Master in Animal Science by Universidade Federal do Maranhão, Postgraduate Program in Animal Science, Chapadinha, Maranhão, Brazil
http://lattes.cnpq.br/6359352971253462

Ivone Rodrigues Silva
Doctor in the program of: Universidade Federal do Piauí, UFPI- Campus Teresina, Piauí-PI, Brazil
http://lattes.cnpq.br/6466497459664213

Pedro Pascoal de Sousa Filho
Agricultural scientist, Centro Federal de Educação Tecnológica do Maranhão, CEFET, MA, Brazil
http://lattes.cnpq.br/8615912114096294

Anágila Janenis Cardoso Silva
Agronomist by: Universidade Federal do Maranhão, PhD student in Biodiversity and Biotechnology, Bio Norte, São Luís-MA, Brazil
http://lattes.cnpq.br/9448358762145149

Janayra Cardoso Silva
Master in Animal Science by: Universidade Federal do Maranhão, Postgraduate Program in Animal Science, Chapadinha, Maranhão, Brazil
http://lattes.cnpq.br/9134390141935286

José Gracione do Nascimento Sousa Filho
Master in Animal Science by: Universidade Federal do Maranhão, Postgraduate Program in Animal Science, Chapadinha, Maranhão, Brazil
http://lattes.cnpq.br/3445022716798750

Ana Karoline Sodré
Agronomist, Universidade Estadual do Maranhão, UEMA- Campus São Luís-MA, Brazil
http://lattes.cnpq.br/1000058168679825

Luciana Cordeiro Rosa
Veterinarian, Universidade Estadual do Maranhão, UEMA- Campus São Luís-MA, Brazil
http://lattes.cnpq.br/6805390530327371

Karuane Satutino da Silva Araújo
Master in Health Sciences by:Universidade Federal do Tocantins, UFT- Palmas-TO, Brazil
http://lattes.cnpq.br/1115832947713877

Leandro Reis Costa Santos
Doctor in Soil Science by:Universidade Federal Rural de Pernambuco, UFRPE-Recife-PE, Brazil
http://lattes.cnpq.br/9956340347243955

Abstract: In agricultural experimentation, in general, researchers estimate the precision of experiments using the coefficient of variation (CV) through works suggesting classification ranges of values considering the mean, standard deviation and CV values. In this work, the objective was to study the distribution of CV values of experiments with sheep finished in confinement, proposing ranges that guide researchers in the evaluation of studies. CV data were collected from studies published in Brazilian journals, with emphasis on beef sheep, addressing: weight gain, feed intake, feed conversion, digestibility, ingestive behavior, hot carcass weight, hot carcass yield, weight loss by cooling, loin eye area, fat thickness, final pH (24 hours post-slaughter), cooking weight loss, water holding capacity, shear force, moisture, ash, meat proteins and lipids. Ranges of CV values were obtained for each variable based on the normal distribution, classifying them as low, medium, high and very high. The results obtained indicated that ranges of CV values differed among the different variables, presenting wide variation, therefore, it is necessary to use a specific evaluation range for each variable.
Keywords: Agricultural experimentation, classification ranges, precision.

INTRODUCTION

The coefficient of variation (CV) is a measure of dispersion used to estimate the precision of experiments and represents the standard deviation expressed as a percentage of the mean (OLIVEIRA et al., 2009). The CV makes it possible to compare results from different studies involving the same response variable, allowing the quantification of the research's precision (KALIL, 1977; GARCIA, 1989). The number of replications, plot size, experimental design, environmental heterogeneity and the genetic diversity of the animals influence the experimental error (MOHALLEM et al, 2008).

In equal conditions, the experiment with the lowest coefficient of variation is more accurate (GARCIA, 1989). According to Snedecor and Cochran (1980) the distribution of the CV makes it possible to establish ranges of values that guide researchers on the validity of their experiments.

Articles are published with indications of low experimental precision, often due to the lack of adequate reference values for comparison (JUDICE et al., 2002). In general, in the absence of specific tables, agricultural science researchers have compared the VC results of their experiments with those suggested by Pimentel-Gomes (2000) who considers VC values to be low, when lower than 10%; medium, when they are between 10% and 20%; high, when they are between 20% and 30% and very high, when they are above 30%. These limits were proposed by the author in 1965, and the book went through revisions and re-editions without, however, changing them.

This classification, in addition to being based on agricultural data, is being used to classify coefficients of variation of different variables indiscriminately within the experiment. Therefore, in the evaluation and interpretation of the statistical results obtained through experimentation, it is recommended to explore all available information so that the researcher, when reaching his conclusions, is as safe and correct as possible. Data analysis becomes more informative when, in addition to the average, some measures of dispersion or variability are obtained.

Therefore, the objective of this study was to evaluate the distribution of CV in experiments with beef sheep finished in confinement, considering their main response variables, to establish classification ranges that guide the researcher regarding the accuracy of the data of his research.

METHODOLOGY

Coefficients of variation were tabulated from several studies on beef sheep published in Brazilian journals. The variables that occurred most frequently in the research were selected, which are: weight gain, feed intake (DM, OM, CP and NDF), feed conversion, digestibility (DM, OM, CP and NDF) and ingestive behavior (feeding, rumination and idle time in min/day) and hot carcass weight (PCQ), hot carcass yield (RQC), chilling weight loss (PPR), rib eye area (AOL), fat thickness (EG), final pH (24 hours post-slaughter), weight loss by cooking (PPC), water holding capacity (WRC), shear force (FC), moisture, ash, meat proteins and lipids.

In this work, the experimental projects were not specified, considering the conclusion of Estefanel et al. (1987), according to which such aspects did not significantly influence the CV values, assuming that the research layout aims, in principle, to attenuate the possibility of experimental error.

To test the fit of the data to the normal distribution, the Shapiro-Wilk-1965 test in the SAS (Statistical Analysis System) was used. Considering as a criterion for rejection of the hypothesis H0 of normality, the critical region of the test such that $P(W<w) < 0.05$, where w is the value of the test statistic. For variables that did not show normal distribution, logarithmic transformation was used as suggested by Estefanel et al. (1987), obtaining the classification ranges and, later, returning the data to the original scale.

For each response variable, the following were obtained: highest value, lowest value, mean and standard deviation.

The criterion used to establish the CV ranges was the one proposed by Garcia (1989), who considers the following ranges and respective classifications for data with an approximately normal distribution: low (CV ££ x-s); mean (x-s < CV ££ x+ s); high (x+s < CV £xx+ 2s); very high (CV > x+ 2s), where x and s are, respectively, the mean and standard deviation of the CV values.

RESULTS AND DISCUSSION

Tables 1 and 2 present the statistical results obtained from the CV values found in the Brazilian literature with experiments related to the performance of beef sheep. By the Shapiro-Wilk test, the variables studied showed a distribution close to normality (P > 0.03) (Table 01).

As demonstrated by its average CV (Table 01), the digestibility of dry matter, organic matter and protein are variables with different behavior from the others, the high CV is less than 10%. This is because the estimate of digestibility by the conventional method, the method used in this work, that is, total collection of feces through collection bags, is the one with the highest degree of confidence (LANÇANOVA et al., 2001).

Analyzing the methodology proposed by Costa et al. (2002), Table 02 must be used as a reference by the researcher to verify whether the CV results obtained in their studies are or are not within an expected range of values.

When comparing the classification ranges found (Table 02) with the one proposed by Gomes (1990), in which CV values lower than 10 are considered low, the information disparity is evident. Because in this table, each variable presented specific CV ranges of values, justifying the need to consider the nature of the CV classification variable.

Among the characteristics evaluated, only rumination time (min/day) had a VC classification range similar to that recommended by Pimentel-Gomes in 1985. This variable had the highest mean VC. According to Mertens (1997), the rumination time varies according to the size of the food particles, particles smaller than 1.18 mm pass through the rumen without the need for rumination, whereas particles with an average size, above 8 mm, cause the food stays longer in the gastrointestinal tract (Castro et al., 2009).

Another factor that interferes in the rumination time is the fiber content, especially the neutral detergent fiber (NDF) content (COLENBRANDER et al., 1991). Foods with a high content of NDF (BOEVER et al., 1990; OBA and ALLEN, 2000), or NDF with low degradability (MCQUEEN and ROBINSON, 1996), need to be chewed and, mainly ruminated for a longer period of time.

For the variables DMS, BPD and BMD, a CV above 7.9, 8.3 and 13.5%, respectively, are considered very high, unlike what was advocated by Pimentel Gomes (1985).

The variables consumption of DM, OM, CP and NDF present higher CV values, compared to the other characteristics, this can be explained through the mechanisms that govern the control of food intake by two theories: one due to the physical limitation of the digestive tract and the other by the animal's physiological and metabolic requirements (VAN SOEST, 1994).

The application of the Shapiro-Wilk normality test showed that the data of carcass characteristics studied had a distribution that did not differ from the normal (Table 03).

By means of the coefficients of variation observed (Table 03), there is a tendency for the variables PPR, AOL, EG, FC and meat lipid content to present higher CV values, compared to the other analyzed variables, especially PPR, which can be associated with the cooling speed of a carcass, being dependent on several factors: specific heat of the carcass, weight, amount of external fat, thermal conductivity, temperature of the

Variables	Quantity	Minimum	Maximum	Medium	Standard deviation	Shapiro-Wilk	
						W	P (One sided D)
CA	42	2,25	21,36	10,61	5,32	0,92	0,0310
CMS	33	3,67	20,3	10,69	4,41	0,91	0,0320
CMO	19	0,24	18,88	9,25	6,88	0,93	0,3799
CPB	29	6,39	27,43	14,28	6,11	0,91	0,0385
CFDN	24	6,4	27,55	13,23	5,15	0,89	0,0380
DMS	23	2,61	11,25	5,13	2,14	0,96	0,1232
DMO	29	0,63	14,61	6,39	3,60	0,92	0,0324
DPB	23	2,03	10,34	9,11	2,39	0,90	0,0665
DFDN	24	4,17	14,08	8,54	2,59	0,91	0,1124
REF	14	7,49	30,81	19,25	6,15	0,90	0,8567
RUM	14	8,74	31,14	16,31	5,88	0,90	0,4026
OC	14	8,05	26,08	14,34	5,10	0,91	0,2439

CA: Food conversion; CMS: Dry matter consumption; CMO: Consumption of organic matter; CPB: Crude protein consumption; CFDN: Consumption of neutral detergent fiber; DMS (%): Digestibility of dry matter; BMD (%): Digestibility of organic matter; BPD (%): Crude protein digestibility; DFND (%): Digestibility of fiber in neutral detergent; REF: Meal; RUM: Rumination; OC: Idle (Min/day).

Table 01. Normality test and descriptive statistics of the coefficients of variation of the variables studied in the published experiments on beef sheep

Variables	≤ Low	Medium	High	Very high >
	CV≤ X-S	X-S<CV≤ X+S	X+S<CV≤ X+ 2S	>X+ 2S
CA	<5,41	5,41<CV≤ 11,72	11,72<CV≤ 14,88	>18,61
CMS	<5,55	5,55<CV≤ 15,17	15,17<CV≤ 19,68	>19,68
CMO	<4,33	4,33<CV≤ 21,04	21,04<CV≤ 29,39	>29,39
CPB	<8,97	8,97<CV≤ 22,90	22,90<CV≤ 29,86	>29,86
CFDN	<8,99	8,99<CV≤ 22,59	22,59<CV≤ 29,39	>29,39
DMS	<2,99	2,99<CV≤ 6,29	6,29<CV≤ 7,93	>7,93
DMO	<2,63	2,63<CV≤ 9,94	9,94<CV≤ 13,59	>13,59
DPB	<2,56	2,56<CV≤ 6,43	6,43<CV≤ 8,37	>8,37
DFDN	<4,80	4,80<CV≤ 13,32	13,32<CV≤ 17,58	>17,58
REF	<13,11	13,11<CV≤ 25,40	25,40<CV≤ 31,55	>31,55
RUM	<10,43	10,43<CV≤ 22,19	22,19<CV≤ 28,07	>28,07
OC	<9,24	9,24<CV≤ 19,45	19,45<CV≤ 24,55	>24,55

CA: Food conversion; CMS: Dry matter consumption; CMO: Consumption of organic matter; CPB: Crude protein consumption; CFDN: Consumption of neutral detergent fiber; DMS (%): Digestibility of dry matter; BMD (%): Digestibility of organic matter; BPD (%): Crude protein digestibility; DFND (%): Digestibility of fiber in neutral detergent; REF: Meal; RUM: Rumination; OC: Idle (Min/day).

Table 02. Classification ranges for the coefficients of variation (%) of the variables commonly evaluated in performance experiments with beef sheep.

Variables	Quantity	Minimum	Maximum	Medium	Standard deviation	Shapiro-Wilk	
						W	P (one-sided D)
PCQ (Kg)	54	3,13	20,56	9,71	4,55	0,94	0,0418
RCQ (%)	30	3,1	7,85	4,88	1,3	0,93	0,1371
PPR (%)	38	8,46	73,83	34,62	18,52	0,93	0,0934
AOL (cm^2)	31	9,83	34,42	16,25	6,79	0,91	0,0419
EG (mm)	24	19,15	59,7	33,82	10,55	0,89	0,0434
pH final	23	0,17	4,97	1,54	1,38	0,92	0,1976
PPC (%)	27	1,96	13,48	8,65	3,48	0,93	0,3589
CRA (%)	18	1,12	8,1	4	2	0,94	0,3213
FC (KgF)	33	4,37	36,3	19,76	8,73	0,91	0,1823
Moisture	26	0,04	2,99	0,89	0,72	0,92	0,0704
Ashes	21	0,93	12,02	3,88	3,75	0,92	0,1886
Proteins	27	0,68	8,41	2,7	2,16	0,92	0,1483
Lipid	25	0,62	45,85	18,39	13,71	0,91	0,0791

Hot carcass weight (PCQ), Hot carcass yield (RCQ), Chilling weight loss (PPR), Loin oil area (AOL), Fat thickness (EG), final pH (24 hours post slaughter), Cooking Weight Loss (PPC), Water Holding Capacity (WRC), Shearing Force (FC), Moisture, Ash, Proteins and Lipids.

Table 03. Normality test and descriptive statistics of the coefficients of variation of the variables studied in beef sheep carcasses.

Variables	Low	Medium	High	Very high
	<(X-S)	(X-S) a (X+S)	(X+S) a (X+2S)	> (X+2S)
PCQ (Kg)	< 5,15	5,15 a 14,26	14,26 a 18,81	> 18,81
RCQ (%)	< 3,58	3,58 a 6,18	6,18 a 7,49	> 7,49
PPR (%)	< 16,09	16,09 a 53,14	53,14 a 71,66	> 71,66
AOL (cm2)	< 9,46	9,46 a 23,04	23,04 a 29,83	> 29,83
EG (mm)	< 23,27	23,27 a 44,37	44,37 a 54,92	> 54,92
pH final	< 0,16	0,16 a 2,92	2,92 a 4,30	> 4,30
PPC (%)	< 5,17	5,17 a 12,13	12,13 a 15,60	> 15,60
CRA (%)	< 1,99	1,99 a 6,00	6,00 a 8,00	> 8,00
FC (KgF)	< 11,03	11,03 a 28,49	28,49 a 37,23	> 37,23
Moisture	< 0,17	0,17 a 1,60	1,60 a 2,32	> 2,32
Ashes	< 0,13	0,13 a 7,63	7,63 a 11,38	> 11,38
Proteins	< 0,54	0,54 a 4,86	4,86 a 7,02	> 7,02
Lipid	< 4,68	4,68 a 32,10	32,10 a 45,82	> 45,82

Hot Carcass Weight (PCQ), Hot Carcass Yield (RQC), Chilling Weight Loss (PPR), Loin Oil Area (AOL), Fat Thickness (EG), Final Ph (24 hours post slaughter), Cooking Weight Loss (PPC), Water Holding Capacity (WRC), Shearing Force (FC), Moisture, Ash, Proteins and Lipids.

Table 04. Classification ranges for the coefficients of variation (%) of the variables commonly evaluated in beef sheep carcasses

refrigeration chamber and air circulation speed (MEDEIROS, 2006). Carcass fat reduces heat dissipation and PPR is closely linked to carcass EG, noting the variability of the CVs of both. The greater the carcass weight and greater fat coverage, therefore, the longer the cooling time (URANO et al., 2006).

The measurement of AOL is usually performed by tracing the muscle *Longissumus dorsi* with the help of tracing paper, which may be the main source of variation, since the perfection in the tracing performed by the researcher will measure the AOL without under or overestimating it, giving the variable the lowest possible variation index.

The lipid content of the meat, as a variable of laboratory measurement, must give a CV without major changes, however, we can see (Table 3) that there are large oscillations and this may be linked to the extraction methods used in the analyzed works, since, the Soxhlet method, the values for lipids are generally higher than those found by the Folch method. The results may be related to the fact that in the Soxhlet extraction, there is a "dragging" of free lipids (triglycerides and free fatty acids), in contrast to the Folch method, whereby only lipids bound to proteins and carbohydrates are extracted.

The exception is in relation to the final pH, moisture, ash and proteins, which showed an average well below the other variables, as it is easy to determine in the laboratory. The variable, water retention capacity, also showed a similar behavior, since it is directly related to the meat's ability to retain its moisture or water during the application of external forces (CEZAR and SOUZA, 2007).

Therefore, the digestibility variable presented the lowest average coefficients of variation, while the time in meal variable presented the highest CV averages. Regarding the carcass characteristics, the variables weight loss by cooling, loin eye area, fat thickness, shear force and lipid content of the meat presented the highest CVs, whereas the final pH, moisture, ashes and proteins presented an average well below the other variables. Thus, it is not possible to use the fixed values stipulated by Gomes (1990), as this author stipulated the CV classification ranges based on agronomic variables, however, in the confinement cutting sheep industry, the uncontrolled variations, or fruits of the chance, are relatively smaller than those found in agronomic experiments. This is because we work with animals in more controlled environments, and we can even work with high homogeneity. Therefore, these ranges stipulated by Gomes (1990), despite being widely used as reference values, lead to a great bias in the conclusions of experiments in the area of beef sheep farming.

CONCLUSIONS

The classification ranges of the coefficients of variation found for the analyzed variables can be used as a reference to determine the experimental precision.

The coefficients of variation in studies with beef sheep have their own characteristics and differ significantly from the ranges proposed by Gomes (1990) for most of the variables analyzed.

The ranges of CV values differed among the different variables, presenting wide variation, therefore, it is necessary to use a specific evaluation range for each variable.

REFERENCES

CASTRO, M.V.L.; NAVES, M.M.V.; OLIVEIRA, J.P. et al. **Rendimento industrial e composição química de milho de alta qualidade proteica em relação a híbridos comerciais.** Pesquisa Agropecuária Tropical, v.39, p.233-242, 2009.

CEZAR M.F. & SOUZA W.H. **Carcaças Ovinas e Caprinas: obtenção, avaliação e classificação**. Uberaba, MG: Edit. Agropecuária Tropical, 147p, 2007.

COLENBRANDER, V.F.; NOLLER, C.H.; GRANT, R.J. **Effect of fiber content and particle size of alfalfa silage on performance and chewing behavior.** Jounal Dairy Science, v.74, p.2681-2690, 1991.

COSTA, N. H. de A. D.; SERAPHIN, J. C.; ZIMMERMANN, F. J. P. **Novo método de classificação de coeficientes de variação para a cultura de arroz de terras altas.** Pesquisa Agropecuária Brasileira, Brasília, v. 37, n. 3, p. 243-249, mar. 2002.

DE BOEVER, J.L.; ANDRIES, D.I.; BRABANDER, D.L. et al. **Chewing activity of ruminants as a measure of physical structure A review of factors affecting it.** Animal Feed Science Technol., v.27, p.281-291, 1990.

FEDERER, W. T. **Experimental design**. New York: J. Wiley, 1957. 611 p.

GARCIA, C.H. **Tabelas para classificação do coeficiente de variação**. Piracicaba: IPEF, 1989. 12p. (Circular técnica, 171).

GOMES, F.P. **Curso de estatística experimental**. 12.ed. São Paulo: Nobel, 1990. 467p.

JUDICE, M.G.; MUNIZ, J.A.; CARVALHEIRO, R. **Avaliação do coeficiente de variação na experimentação com suínos.** Ciência e Agrotecnologia, v.23, p.170-173, 1999.

KALIL, E.B. **Princípios de técnica experimental com animais**. Piracicaba: ESALQ, 1977. 210 p.

McQUEEN, R.E.; ROBINSON, P.H. **Intake behavior, rumen fermentation and milk production of dairy cows as influenced by dietary levels of fementable neutral detergent fiber. Can.** Journal Animal Science, v.76, p.357-365, 1996.

MEDEIROS, G. R. **Efeito de níveis de concentrado sobre o desempenho, característica de carcaça e componentes não carcaça de ovinos Morada Nova em confinamento**. Recife: Universidade Federal Rural de Pernambuco, 2006 108p. Tese (Doutorado em Zootecnia) - Universidade Federal Rural de Pernambuco, 2006.

MERTENS, D.R. **Creating a system for meeting the fiber requirements of dairy cows.** Journal Dairy Science, v.80, p.1463-1481, 1997.

MOHALLEM, D. F; TAVARES, M; SILVA, P. L; GUIMARÃES, E. C; FREITAS, R. F. **Avaliação do coeficiente de variação como medida da precisão em experimentos com frangos de corte.** Arquivos Brasileiros de Medicina Veterinária e Zootecnia, v.60, n.2, p.449-453, 2008.

OBA, M.; ALLEN, M.S. **Effects of brown midrib mutation in corn silage on productivity of dairy cows fed two concentrations of dietary neutral detergent fiber. 1. Feeding behavior and nutrient utilization.** Journal Dairy Science, v.83, p.1333-1341, 2000.

OLIVEIRA, R. L; MUNIZ, J. A; ANDRADE, J. B; REIS, R. L. **Precisão em ensaios com a cultura do feijão.** Ciência e Agrotecnologia, v. 33, p.113-119, 2009

PIMENTEL-GOMES, Curso de Estatística Experimental. Piracicaba-SP. ESALQ/USP, 1985.

PIMENTEL-GOMES, F. **Curso de estatística experimental**. 13. ed. São Paulo: Nobel, 2000.479 p.

SHAPIRO, S.S; WILK, M. B. **An analysis of variance test of normality** (complete samples). Biometrika, v.52, n.3-4, p.591-611, 1965.

SNEDECOR, G.W.; COCHRAN, W.G. Statistical methods. 7.ed. Ames: The Iowa State University, 1980. 593p.

URANO, F. S.; PIRES, A. V.; SUSIN, I. **Desempenho e características da carcaça de cordeiros confinados alimentados com grão de soja.** Pesquisa Agropecuária Brasileira, v.41, n.1, p.1525-1530, 2006.