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Sample size for estimate the average of *Passiflora caerulea* fruits traits

Dimensionamento amostral para estimação da média de caracteres de frutos de *Passiflora caerulea*

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ABSTRACT

*The aim of this research was to determine the sample size needed to estimate the average of wild passion fruit (**Passiflora caerulea**) traits. It was collected randomly, 133, 99 and 133 fruit of wild passion fruit in 30, 21 and 29 plants, located respectively, in the cities of São Borja, Itaqui and Uruguaiana, on the west border of Rio Grande do Sul, Brazil, totaling 365 fruits harvested in 80 plants. In each fruit were measured ten traits: width, length, fruit, skin, and pulp weight, pulp yield, luminosity and tone of skin and pulp. Then, central tendency, dispersion and distribution measures were calculated and the normality of the data checked. After, it was determined the sample size needed to estimate the average for each character, assuming estimation errors equal to 1, 2, ..., 10% of the mean estimate with confidence levels of 95% and 99%. In wild passion fruit, 12 fruits are sufficient to estimate the mean of luminosity and tone of the skin and pulp, with an estimation error of 5% of the mean and 95% confidence, regardless of the evaluation location (São Borja, Itaqui or Uruguaiana). In this same level of accuracy 36 fruits are needed to estimate the width and length, 52 fruits to estimate the pulp yield and 319 fruits for the evaluation of the fruit, skin and pulp weight.*

Key words: *wild passion fruit, experimental precision, experimental planning.*

RESUMO

*O objetivo deste trabalho foi determinar o tamanho de amostra necessário para a estimação da média de caracteres de frutos de maracujá-do-mato (**Passiflora caerulea**). Foram colhidos, aleatoriamente, 133, 99 e 133 frutos de maracujá-do-mato em 30, 21 e 29 plantas localizadas, respectivamente, nos municípios de São Borja, Itaqui e Uruguaiana, na fronteira oeste do estado do Rio Grande do Sul, Brasil, totalizando 365 frutos colhidos em 80 plantas. Em cada fruto, foram mensurados dez caracteres: largura, comprimento, massa do fruto, da casca e da polpa, rendimento de polpa, luminosidade e tonalidade da casca e da polpa. A seguir, foram calculadas medidas de tendência central, de dispersão e de distribuição e verificada a normalidade dos dados. Posteriormente, foi determinado o tamanho de amostra necessário para a estimação da média de cada caractere, assumindo erros de estimação iguais a 1, 2, ..., 10% da estimativa da média com graus de confiança de 95% e 99%. Em maracujá-do-mato, 12 frutos são suficientes para a estimação da média de luminosidade e tonalidade da casca e da polpa, com erro de estimação de 5% da média e 95% de confiança, independentemente do local de avaliação (São Borja, Itaqui ou Uruguaiana). Nesse mesmo nível de precisão, são necessários 36 frutos para a estimação da largura e do comprimento, 52 frutos para a estimação da média de rendimento de polpa e 319 frutos para a avaliação das massas do fruto, da casca e da polpa.*

Palavras-chave: *Maracujá-do-mato, precisão experimental, planejamento experimental.*

INTRODUCTION

The species ***Passiflora caerulea*** belongs to the ***Passifloraceae*** family and it is popularly known as wild passion, blue passion flower or red-pulp passion. According to MENDIONDO & AMELA GARCIA (2006), ***P. caerulea*** is the ***Passifloraceae*** family species most widely distributed in Latin America in the last century. As

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stated in DHAWAN et al. (2004), ***P. caerulea*** is native from Brazil and the fruit has been used for diuretics, painkillers, and sedatives purposes. The authors also pointed out that this species roots have been used due to its anthelmintic action. As reported by BUSILACCHI et al. (2008), the aerial part of ***P. caerulea*** is used in the Argentinean pharmaceutical industry and traditional medicine to obtain compounds related to its sedative action. Moreover, FELIÚ-HEMMELMANN et al. (2013) verified that animals that received ***P. caerulea*** infusion decreased biomarkers associated with physiological stress, proving the phytotherapic action of this plant species. The wild passion plant has also been used as rootstocks of commercial passion fruit plants. In this sense, FUHRMANN et al. (2014) emphasized that ***P. caerulea*** demonstrated high degree of resistance to bacterial spot disease caused by ***Xanthomonas axonopodis*** pv. ***passiflorae***, allowing it to be used as a disease resistance source.

The correct sample size dimensioning (number of plants and/or number of fruits) is required to have reliability in results obtained in research involving ***P. caerulea*** and other crops. According to BUSSAB & MORETTIN (2011), the sample size is proportional to the variability of the data and the desired reliability, being inversely proportional to the *a priori* error allowed by the researcher. The sample size dimensioning has been studied in several fruits, such as for the evaluation of fruit traits of peach (TOEBE et al., 2011, 2012) and apple cultivars (MIRANDA et al., 2007; TOEBE et al., 2011, 2014), evaluated at harvest and post-harvest. Furthermore, AVANZA et al. (2010) established the sample size for measuring the growth pattern and diameter of orange fruits 'Valencia late' and BARRY et al. (1999) reported the sample size required to estimate the juice content, total soluble solids, acidity, and ratio of orange fruits 'Valencia'.

In ***Passifloraceae*** family species, the sample size was determined to characterize the postharvest quality (COELHO et al., 2011) and for the characterization of pulp residues of yellow passion fruit (***Passiflora edulis*** f. ***flavicarpa***) (OLIVEIRA et al., 2011). Further, STORCK et al. (2014) determined the number of plants per plot and the plot number required for the evaluation of yellow passion fruit genotypes. However, sample size dimensioning studies to evaluate wild passion fruits were not found in the literature. Therefore, the aim of this research was to determine the sample size required to estimate the mean of fruit traits of wild passion (***Passiflora caerulea***).

MATERIALS AND METHODS

In November 2011, 133, 99, and 133 wild passion fruits (***Passiflora caerulea***) were randomly harvested in 30, 21, and 29 plants located, respectively, in the cities of São Borja, Itaqui, and Uruguaiana, on the west border of Rio Grande do Sul, Brazil, totaling 365 fruits harvested in 80 plants. All evaluated plants were georeferenced and they were located at the coordinates 28º40'S and 55º58'W of São Borja and 29º33'S and 56º51'W of Uruguaiana, with altitude ranging from 58.0 to 97.5 meters above the sea level. The 80 plants were randomly chosen and a maximum of five fruits per plant was harvested. These fruits were also randomly chosen at the physiological maturity stage in a single harvest. In some plants, the total number of fruits was less than five because they did not have that number of fruits in physiological maturity stage.

Immediately after harvest, the fruits were transported to the Interdisciplinary Biology Laboratory of the Universidade Federal do Pampa (Unipampa), campus of Itaqui, state of Rio Grande do Sul, located in the geographical coordinates of 29º09'S and 56º33'W. Subsequently, it was held measurements of the following traits in each fruit: width and length of the fruit, in mm, utilizing a caliper; fruit, skin, and pulp weight, in grams, utilizing a digital scale; pulp yield in % obtained from the ratio between pulp weight and total fruit weight; and, luminosity and tone of the skin and pulp, determined by electronic colorimeter with the Minolta CR310 model, as described by TOEBE et al. (2011), wherein two measurements were performed in opposite equatorially areas of each fruit to measure the luminosity and tone of the skin.

For each of the ten traits measured at each location (São Borja, Itaqui, and Uruguaiana), and overall (sum of the evaluated fruits in the three locations), it was calculated the statistics: minimum and maximum values, mean, median, standard deviation, variance, coefficient of variation, kurtosis, skewness and the p-value of normality Kolmogorov-Smirnov test. Subsequently, the means for each of the ten traits evaluated in the cities of São Borja, Itaqui, and Uruguaiana were compared through the t test for independent samples, adopting α=5% of the probability of error and bootstrap resampling with 10,000 simulations.

For each trait evaluated at each location (São Borja, Itaqui, and Uruguaiana) and overall, it was calculated the sample size (η) for the semi-amplitudes of the confidence interval (estimation

errors) equal to 1, 2, ..., 10% of the estimated mean (m) with degrees of confidence (1-α) of 95% and 99%. For this, it was used the expression: $\eta=(t^2_{\alpha/2}.s^2)/(\text{estimation error})^2$ (BUSSAB & MORETTIN, 2011), being $t_{\alpha/2}$ the critical value of Student's t-test distribution, whose area on the right is equal to α/2 with (n-1) degrees of freedom, adopting α=5% and α=1% of the probability of error and an estimated variance of s^2. Thereafter, η was fixed in 133, 99, 133, and 365 fruits, respectively, for the evaluation sites of São Borja, Itaqui, Uruguaiana, and in overall. Moreover, the estimation error as a percentage of the estimated mean (m) was calculated for each trait through the expression: estimation error= $(100t_{\alpha/2}. s)/(\sqrt{\eta}m)$, where s is the estimated standard deviation. Statistical analyzes were performed using the GENES program (CRUZ, 2013) and Microsoft Office Excel® application.

RESULTS AND DISCUSSION

Overall, the means of the fruits evaluated in Itaqui and Uruguaiana were not statistically different (P>0.05) in length and fruit, skin, and pulp weights. These values are greater (P≤0.05) than the means verified for these traits in fruits collected in São Borja (Table 1). Pulp yield did not differ between the three locations, as well as the tone of the skin. Luminosity of the skin and pulp presented the greatest mean in fruits collected in Uruguaiana and tone of the pulp exhibited higher means in fruits collected in São Borja. The mean of fruit length (39.58mm≤mean≤45.18mm) was lower than the value obtained by SOUSA et al. (2012) in an access of ***P. cincinnata*** with mean of 50.36mm. Moreover, the mean of fruit width (31.54mm≤mean≤35.92mm) and the mean of fruit weight (14.25g≤mean≤17.67g) were also lower than those obtained by SOUSA et al. (2012) of 53.14mm and 74.41g, respectively. However, it has to be emphasized that it was not found data in the literature characterizing fruits of ***P. caerulea*** that could be compared and discussed with the data of this study.

It was found that four, three and three of the ten evaluated traits presented greater coefficients of variation scores (CV), respectively, in the cities of São Borja, Itaqui, and Uruguaiana (Table 1). These data indicated that there was no tendency of greater or lower variability among evaluation sites and the CV scores were similar to those obtained with the data from the three sites combined. At the three sites and in the overall, there was wide variability of the coefficient of variation among the ten measured traits and the CV values increased in the following order: skin luminosity (3.88%≤CV≤4.20%); skin tone, luminosity and tone of pulp (6.60%≤CV≤8.59%); width and length of fruits (11.28%≤CV≤15.11%); pulp yield (14.69%≤CV≤18.16%); and fruit, skin, and pulp weight (34.95%≤CV≤44.94%). The lowest CV score of skin luminosity in relation to the pulp luminosity can be explained in terms of the first obtained by averaging two measurements at opposite fruit areas and the second one obtained from a single measurement. These data point to increasing variability and possibly increasing sample size for luminosity and tone of skin and pulp, fruit length and width, and pulp yield measurements, and greater variability between traits related to fruit, pulp, and skin weight.

With the exception of pulp tone assessed in fruits of São Borja and Uruguaiana, all other traits adjusted to the normal distribution (P≥0.13), even with some cases statistically significant (P≤0.05) of kurtosis (platykurtic or leptokurtic) and skewness (negative or positive) (Table 1). Considering the three locations combined, the normality of the data was not verified only for skin weight and tone of the skin and pulp, which can be related to the high number of evaluated fruits (n=365 fruits). Thus, it can be inferred that the data are suitable to estimate the sample size by the Student's t-test distribution.

The sample size to estimate the mean of ten traits, with estimation error equal to 1% of the mean and 95% of confidence, in fruits from São Borja fluctuated between 59 and 6,128 fruits, respectively for the evaluation of skin luminosity and skin weight (Table 2). In the same precision and confidence level, the sample size ranged among 70 and 7,953 fruits, among 59 and 6,098 fruits, and among 62 and 6,832 fruits, respectively, to evaluate the skin luminosity and pulp weight of fruits deriving from Itaqui, Uruguaiana, and in the overall mean. For the mean estimation of ten traits with estimation error equal to 1% of the mean and 99% of confidence, the sample size ranged among 103 and 10,698 fruits, among 122 and 13,936 fruits, among 103 and 10,645 fruits, and among 108 and 11,845 fruits, respectively, to evaluate fruits deriving from São Borja, Itaqui, Uruguaiana, and in the overall mean (Table 3). Sample sizes (number of fruits) were similar among the evaluation sites for the same trait and precision level.

High variability of sample size among traits has also been observed in other fruits. In this sense, a study developed by TOEBE et al. (2014) reported that the sample size to estimate the mean of

Table 1 - Measurement unit (Un), minimum (Min), maximum (Max), mean, median, standard error (SE), variance (Var), coefficient of variation (CV%), kurtosis (KT), skewness (SK) and p-value of the Kolmogorov-Smirnov test for ten traits of wild passion fruits (***Passiflora caerulea***) evaluated in three cities of the west border of Rio Grande do Sul, Brazil.

Fruit trait	Un	Min	Max	Mean[(1)]	Median	SE	Var	CV%	KT[(2)]	SK[(3)]	p-value
Local: São Borja / n=133 fruits of 30 plants											
Width	mm	23.88	41.55	31.54^{c}	31.35	0.33	14.70	12.16	2.86^{ns}	0.38^{ns}	0.71
Length	mm	29.68	49.92	39.58^{b}	39.20	0.39	19.94	11.28	2.42^{ns}	0.11^{ns}	0.80
Fruit weight	g	5.02	30.27	14.25^{b}	13.67	0.44	25.78	35.64	3.46^{ns}	0.65*	0.61
Skin weight	g	3.21	18.37	7.21^{b}	6.60	0.25	8.14	39.57	5.60*	1.33*	0.25
Pulp weight	g	1.19	14.22	7.04^{b}	6.92	0.24	7.64	39.26	2.54^{ns}	0.16^{ns}	0.97
Pulp yield	%	23.52	69.30	48.89^{a}	49.03	0.77	78.85	18.16	2.87^{ns}	-0.27^{ns}	0.74
Skin luminosity	un.	57.86	74.09	66.26^{ab}	66.29	0.22	6.62	3.88	4.03*	-0.37^{ns}	0.59
Skin tone	º	52.47	73.66	62.34^{a}	62.18	0.36	16.95	6.60	3.12^{ns}	0.49*	0.54
Pulp luminosity	un.	26.87	42.08	32.34^{b}	32.03	0.20	5.41	7.19	4.78*	0.79*	0.43
Pulp tone	º	25.88	40.33	30.42^{a}	30.10	0.23	6.83	8.59	5.32*	1.31*	0.03
Local: Itaqui / n = 99 fruits of 21 plants											
Width	mm	24.50	44.03	35.92^{a}	36.79	0.43	17.91	11.78	3.02^{ns}	-0.66*	0.29
Length	mm	29.49	63.69	45.04^{a}	45.45	0.66	43.52	14.65	3.81^{ns}	0.23^{ns}	0.27
Fruit weight	g	5.50	34.89	17.67^{a}	18.16	0.66	42.52	36.91	2.36^{ns}	-0.01^{ns}	0.46
Skin weight	g	3.36	20.54	9.11^{a}	8.84	0.32	10.14	34.95	4.20*	0.71*	0.68
Pulp weight	g	1.59	17.52	8.56^{a}	8.42	0.39	14.78	44.94	2.31^{ns}	0.08^{ns}	0.64
Pulp yield	%	22.30	63.26	46.85^{a}	47.16	0.82	65.97	17.34	3.57^{ns}	-0.62*	0.62
Skin luminosity	un.	58.72	73.20	65.60^{b}	65.47	0.28	7.59	4.20	2.95^{ns}	0.04^{ns}	0.85
Skin tone	º	53.63	76.89	62.63^{a}	61.47	0.47	21.94	7.48	2.78^{ns}	0.46^{ns}	0.16
Pulp luminosity	un.	25.81	38.67	32.54^{ab}	32.35	0.26	6.55	7.87	2.97^{ns}	0.23^{ns}	0.36
Pulp tone	º	25.25	35.46	29.68^{b}	29.13	0.23	5.08	7.60	2.90^{ns}	0.56*	0.24
Local: Uruguaiana / n = 133 fruits of 29 plants											
Width	mm	22.62	43.79	34.35^{b}	33.87	0.36	17.13	12.05	3.05^{ns}	-0.01^{ns}	0.60
Length	mm	33.39	59.85	45.18^{a}	43.94	0.58	44.94	14.84	2.05*	0.24^{ns}	0.39
Fruit weight	g	3.97	32.95	16.20^{a}	14.85	0.51	34.86	36.45	2.97^{ns}	0.43*	0.14
Skin weight	g	2.49	16.92	8.40^{a}	7.65	0.28	10.15	37.90	2.88^{ns}	0.64*	0.13
Pulp weight	g	1.18	19.92	7.79^{a}	7.64	0.27	9.46	39.47	4.36*	0.51*	0.87
Pulp yield	%	27.84	62.07	47.62^{a}	47.75	0.61	48.95	14.69	2.99^{ns}	-0.25^{ns}	0.90
Skin luminosity	un.	59.84	72.88	66.52^{a}	66.54	0.22	6.65	3.88	2.84^{ns}	0.01^{ns}	0.99
Skin tone	º	50.58	79.76	62.76^{a}	61.70	0.44	25.17	7.99	3.95*	0.78*	0.18
Pulp luminosity	un.	26.26	40.55	32.95^{a}	32.60	0.23	7.23	8.16	3.22^{ns}	0.29^{ns}	0.54
Pulp tone	º	25.95	37.93	29.43^{b}	29.02	0.19	4.90	7.52	5.56*	1.36*	0.04
Data from the three cities / n = 365 fruits of 80 plants											
Width	mm	22.62	44.03	33.75	33.65	0.23	19.57	13.11	2.44*	0.01^{ns}	0.96
Length	mm	29.49	63.69	43.10	42.60	0.34	42.38	15.11	2.97^{ns}	0.47*	0.22
Fruit weight	g	3.97	34.89	15.89	14.94	0.31	35.32	37.41	2.77^{ns}	0.42*	0.09
Skin weight	g	2.49	20.54	8.16	7.70	0.17	9.96	38.67	3.75*	0.85*	0.03
Pulp weight	g	1.18	19.92	7.73	7.51	0.17	10.54	42.03	3.18^{ns}	0.37*	0.74
Pulp yield	%	22.30	69.30	47.87	48.04	0.42	64.79	16.81	3.20^{ns}	-0.32*	0.88
Skin luminosity	un.	57.86	74.09	66.18	66.27	0.14	6.99	4.00	3.22^{ns}	-0.13^{ns}	0.92
Skin tone	º	50.58	79.76	62.57	61.80	0.24	21.21	7.36	3.53*	0.64*	0.03
Pulp luminosity	un.	25.81	42.08	32.62	32.30	0.13	6.42	7.77	3.51*	0.44*	0.08
Pulp tone	º	25.25	40.33	29.86	29.36	0.13	5.81	8.07	5.06*	1.18*	0.01

[(1)]The means of each trait measured in three cities (São Borja, Itaqui and Uruguaiana), followed by the same letter not differ by t test, at 5% probability and bootstrap resampling with 10,000 simulations. [(2)] * Kurtosis differs from three by t test at 5% probability. [ns] = non-significant. [(3)] * Skewness differs from zero by t test at 5% probability. [ns] = non-significant.

Table 2 - Sample size (i.e., number of fruits) to estimate the mean of ten traits of wild passion fruits (***Passiflora caerulea***) with estimation error equal to: 1, 2, ..., 10% of estimated mean with 95% confidence level and semiamplitude of the confidence interval (Error %), based on 133, 99, 133 and 365 fruits, respectively, in the cities of São Borja, Itaqui and Uruguaiana and in general.

Fruit trait	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	Error(%)
Local: São Borja / n = 133 fruits of 30 plants											
Width	579	145	65	37	24	17	12	10	8	6	2.09
Length	499	125	56	32	20	14	11	8	7	5	1.94
Fruit weight	4.970	1.243	553	311	199	139	102	78	62	50	6.12
Skin weight	6.128	1.532	681	383	246	171	126	96	76	62	6.79
Pulp weight	6.033	1.509	671	378	242	168	124	95	75	61	6.74
Pulp yield	1.292	323	144	81	52	36	27	21	16	13	3.12
Skin luminosity	59	15	7	4	3	2	2	1	1	1	0.67
Skin tone	171	43	19	11	7	5	4	3	3	2	1.14
Pulp luminosity	203	51	23	13	9	6	5	4	3	3	1.24
Pulp tone	289	73	33	19	12	9	6	5	4	3	1.48
Local: Itaqui / n = 99 fruits of 21 plants											
Width	547	137	61	35	22	16	12	9	7	6	2.36
Length	845	212	94	53	34	24	18	14	11	9	2.93
Fruit weight	5.365	1.342	597	336	215	150	110	84	67	54	7.37
Skin weight	4.811	1.203	535	301	193	134	99	76	60	49	6.98
Pulp weight	7.953	1.989	884	498	319	221	163	125	99	80	8.97
Pulp yield	1.184	296	132	74	48	33	25	19	15	12	3.46
Skin luminosity	70	18	8	5	3	2	2	2	1	1	0.84
Skin tone	221	56	25	14	9	7	5	4	3	3	1.50
Pulp luminosity	244	61	28	16	10	7	5	4	4	3	1.57
Pulp tone	228	57	26	15	10	7	5	4	3	3	1.52
Local: Uruguaiana / n = 133 fruits of 29 plants											
Width	569	143	64	36	23	16	12	9	8	6	2.07
Length	862	216	96	54	35	24	18	14	11	9	2.55
Fruit weight	5.199	1.300	578	325	208	145	107	82	65	52	6.26
Skin weight	5.621	1.406	625	352	225	157	115	88	70	57	6.51
Pulp weight	6.098	1.525	678	382	244	170	125	96	76	61	6.78
Pulp yield	845	212	94	53	34	24	18	14	11	9	2.53
Skin luminosity	59	15	7	4	3	2	2	1	1	1	0.67
Skin tone	251	63	28	16	11	7	6	4	4	3	1.38
Pulp luminosity	261	66	29	17	11	8	6	5	4	3	1.40
Pulp tone	222	56	25	14	9	7	5	4	3	3	1.30
Data from the three cities / n = 365 fruits of 80 plants											
Width	665	167	74	42	27	19	14	11	9	7	1.35
Length	883	221	99	56	36	25	19	14	11	9	1.56
Fruit weight	5.412	1.353	602	339	217	151	111	85	67	55	3.86
Skin weight	5.785	1.447	643	362	232	161	119	91	72	58	3.99
Pulp weight	6.832	1.708	760	427	274	190	140	107	85	69	4.33
Pulp yield	1.094	274	122	69	44	31	23	18	14	11	1.74
Skin luminosity	62	16	7	4	3	2	2	1	1	1	0.42
Skin tone	210	53	24	14	9	6	5	4	3	3	0.76
Pulp luminosity	234	59	26	15	10	7	5	4	3	3	0.80
Pulp tone	253	64	29	16	11	8	6	4	4	3	0.84

Table 3 - Sample size (i.e., number of fruits) to estimate the mean of ten traits of wild passion fruits (***Passiflora caerulea***) with estimation error equal to: 1, 2, ..., 10% of estimated mean with 99% confidence level and semiamplitude of the confidence interval (Error %), based on 133, 99, 133 and 365 fruits, respectively, in the cities of São Borja, Itaqui and Uruguaiana and in general.

Fruit trait	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	Error(%)
----------Local: São Borja / n = 133 fruits of 30 plants----------											
Width	1.010	253	113	64	41	29	21	16	13	11	2.76
Length	870	218	97	55	35	25	18	14	11	9	2.56
Fruit weight	8.676	2.169	964	543	348	241	178	136	108	87	8.08
Skin weight	10.698	2.675	1.189	669	428	298	219	168	133	107	8.97
Pulp weight	10.531	2.633	1.171	659	422	293	215	165	131	106	8.90
Pulp yield	2.254	564	251	141	91	63	46	36	28	23	4.12
Skin luminosity	103	26	12	7	5	3	3	2	2	2	0.88
Skin tone	298	75	34	19	12	9	7	5	4	3	1.50
Pulp luminosity	354	89	40	23	15	10	8	6	5	4	1.64
Pulp tone	504	126	56	32	21	14	11	8	7	6	1.95
----------Local: Itaqui / n = 99 fruits of 21 plants----------											
Width	959	240	107	60	39	27	20	15	12	10	3.12
Length	1.481	371	165	93	60	42	31	24	19	15	3.87
Fruit weight	9.401	2.351	1.045	588	377	262	192	147	117	95	9.75
Skin weight	8.431	2.108	937	527	338	235	173	132	105	85	9.23
Pulp weight	13.936	3.484	1.549	871	558	388	285	218	173	140	11.87
Pulp yield	2.075	519	231	130	83	58	43	33	26	21	4.58
Skin luminosity	122	31	14	8	5	4	3	2	2	2	1.11
Skin tone	386	97	43	25	16	11	8	7	5	4	1.98
Pulp luminosity	428	107	48	27	18	12	9	7	6	5	2.08
Pulp tone	399	100	45	25	16	12	9	7	5	4	2.01
----------Local: Uruguaiana / n = 133 fruits of 29 plants----------											
Width	992	248	111	62	40	28	21	16	13	10	2.74
Length	1.505	377	168	95	61	42	31	24	19	16	3.37
Fruit weight	9.075	2.269	1.009	568	363	253	186	142	113	91	8.27
Skin weight	9.813	2.454	1.091	614	393	273	201	154	122	99	8.59
Pulp weight	10.645	2.662	1.183	666	426	296	218	167	132	107	8.95
Pulp yield	1.475	369	164	93	59	41	31	24	19	15	3.33
Skin luminosity	103	26	12	7	5	3	3	2	2	2	0.88
Skin tone	437	110	49	28	18	13	9	7	6	5	1.82
Pulp luminosity	455	114	51	29	19	13	10	8	6	5	1.85
Pulp tone	387	97	43	25	16	11	8	7	5	4	1.71
----------Data from the three cities / n = 365 fruits of 80 plants----------											
Width	1.152	288	128	72	47	32	24	18	15	12	1.78
Length	1.530	383	170	96	62	43	32	24	19	16	2.05
Fruit weight	9.384	2.346	1.043	587	376	261	192	147	116	94	5.08
Skin weight	10.029	2.508	1.115	627	402	279	205	157	124	101	5.25
Pulp weight	11.845	2.962	1.317	741	474	330	242	186	147	119	5.70
Pulp yield	1.896	474	211	119	76	53	39	30	24	19	2.28
Skin luminosity	108	27	12	7	5	3	3	2	2	2	0.55
Skin tone	364	91	41	23	15	11	8	6	5	4	1.00
Pulp luminosity	405	102	45	26	17	12	9	7	5	5	1.06
Pulp tone	438	110	49	28	18	13	9	7	6	5	1.10

traits of apple 'Royal Gala', with estimation error of 1% of the mean, ranged from 137 to 1,200 fruits at harvest and from 63 to 2,194 fruits after cold storage. Further, in 'Fuji' apples, the authors reported that the sample size varied between 259 and 2,559 fruits at harvest and between 46 and 4,739 fruits after cold storage. In the same precision level, TOEBE et al. (2012) observed that to estimate the mean of traits of peach 'Eldorado', it is necessary to measure 31 to 1,954 fruits at harvest and from 33 to 4,213 fruits after cold storage. For measurement of pulp firmness, luminosity, intensity and tone of the background color of peach epidermis of 'Eragil' and apple 'Royal Gala' under different storage conditions; it was observed sample sizes from 52 to 11,933 fruits and from 111 to 539 fruits, respectively, for peach and apple (TOEBE et al., 2011).

In the present study, high variability of the sample size was observed among traits, requiring 70, 251, 261, 289, 665, 883, 1,292, 5,412, 6,128, and 7,953 fruits, respectively, to evaluate the skin luminosity, skin tone, pulp luminosity, pulp tone, fruit width, fruit length, pulp yield, fruit weight, skin weight, and pulp weight, with a maximum error of no more than 1% of the mean and 95% of confidence, regardless of the evaluation site (Table 2). In general, there was an increase in the sample size in the measurements of luminosity and tone of the skin, luminosity and tone of the pulp, fruit width and length, and pulp yield and greater sample size to measure the weight of fruit, skin, and pulp.

In peach and apple, TOEBE et al. (2011) reported the necessity of larger sample size to assess the pulp firmness when compared to the epidermis background color. In peach 'Eldorado', TOEBE et al. (2012) observed that larger sample sizes are required to estimate the mean of pulp firmness, followed by the mass, ratio, and acidity. In the same study, smaller sample sizes were required to estimate the mean of juice content, length, diameter (greater and smaller), coloring, and total soluble solids. In two apple cultivars, TOEBE et al. (2014) reported that a larger sample size is required to estimate the ethylene production, ratio, respiration, weight, and acidity in relation to the one required for measuring length, pulp firmness, total soluble solids, diameters (greater and smaller), and juice content. Moreover, in orange 'Valencia', BARRY et al. (1999) recommended the measurement of 80 fruits (four fruits/plant×20 plants) to determine the juice content, total soluble solids, acidity, and ratio. Furthermore, in orange 'Valencia late', AVANZA et al. (2010) recommended the measurement of 210 fruits (30 fruits/plant×7 plants) to determine the growth pattern and fruit diameter with estimation error of 2 to 3% of the mean.

It was verified in this research that the measurement of 12 fruits is sufficient to estimate the mean of luminosity and tone of the skin and pulp, regardless the evaluation site with maximum estimation error of 5% of the mean and 95% of confidence. In the same precision, 36 fruits are required to estimate the mean of fruit width and length, 52 fruits to estimate mean of pulp yield, and 319 fruits to evaluate the weight of fruit, skin and pulp (Table 2). Further, the estimation error committed with the use of 133 fruits collected in São Borja fluctuated between 0.67% and 6.79% to measure the luminosity and weight of the skin, with 95% of confidence. In Itaqui, the estimation error committed based on 99 evaluated fruits varied from 0.84% to 8.97%, respectively, for skin luminosity and pulp weight. In Uruguaiana, the estimation error based on 133 evaluated fruits fluctuated between 0.67% and 6.78%, respectively, for skin luminosity and pulp weight. In general, the estimation error based on 365 evaluated fruits ranged from 0.42% to 4.33%, respectively, for skin luminosity and pulp weight, with 95% of confidence.

CONCLUSION

In wild passion fruit, 12 fruits are sufficient to estimate the mean of luminosity and tone of the skin and pulp, with an estimation error of 5% of the mean and 95% confidence, regardless of the evaluation location (São Borja, Itaqui or Uruguaiana). In this same level of accuracy 36 fruits are needed to estimate the width and length, 52 fruits to estimate the pulp yield and 319 fruits for the evaluation of the fruit, skin and pulp weight.

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