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Morphological and chemical characterization of fruits of *Capsicum* spp. accessions

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ABSTRACT

This study aimed to evaluate 69 *Capsicum* accessions from the Germplasm Bank of Universidade Federal de Roraima, for some fruit quality traits. The experiment was performed in a completely random design, with 69 treatments and 3 replications. The 69 accessions were evaluated for fourteen quantitative and two qualitative traits of ripe fruits. Quantitative fruits data were subjected to an analysis of variance, and the means were grouped by Scott-Knott test ($p \leq 0.01$). All characteristics had significant effect of treatments ($p \leq 0.01$) for all evaluated traits. The data showed high genetic variability to future use in a *Capsicum* breeding program. The accessions 33, 44 and 41 showed major values for dry matter content and total soluble solids; these should be used to improve these traits in a paprika breeding program. On the other hand, the accession 48 showed major values for fresh weight, major fruit length and fruit width. The accession 33, belonging to the *Capsicum frutescens* species, with high vitamin C content should be used in a fresh market *Capsicum* breeding program.

Keywords: pepper, chili, breeding, germplasm, Amazonian, fruit quality.

RESUMO

Caracterização morfológica e química de frutos de acessos do gênero *Capsicum* spp

O objetivo deste trabalho foi caracterizar 69 acessos do gênero *Capsicum*, pertencentes ao Banco de Germoplasma de Hortaliças da Universidade Federal de Roraima, quanto a 16 descritores relacionados à qualidade de frutos. O experimento foi conduzido em campo, no delineamento experimental inteiramente casualizado, com três repetições e 10 plantas por parcela. Quatorze descritores quantitativos e dois qualitativos foram utilizados na caracterização e para obtenção de caracteres morfológicos de qualidade. Obteve-se a média de dez frutos por repetição, aleatoriamente dentro de cada acesso, quando os frutos atingiram a maturidade. Os dados quantitativos foram submetidos à análise de variância, com posterior agrupamento das médias pelo teste Scott-Knott. Houve diferença significativa ($p \leq 0,01$) entre os 69 acessos tanto para caracteres morfológicos quanto químicos dos frutos, podendo essa diversidade ser utilizada em programa de melhoramento de *Capsicum*. Se o programa de melhoramento visar à obtenção de maior rendimento de pó, indica-se o uso dos acessos 33, 44 e 41, cujos valores de teor de matéria seca e sólidos solúveis totais foram mais elevados. Entretanto, se o objetivo for o comércio de frutos *in* natura, recomenda-se o acesso 48 que apresentou maiores valores de matéria fresca, comprimento e diâmetro do fruto. O acesso 33, *Capsicum frutescens*, apresentou o maior teor de vitamina C.

Palavras-chave: pimentão, pimenta, melhoramento, germoplasma, Amazônia, qualidade de frutos.

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The genus Capsicum is a member of the Solanaceae family and consists of five domesticated species: *C. annuum*, *C. baccatum*, *C. chinense*, *C. frutescens* and *C. pubescens*. The species *C. pubescens* is the only one who is not grown in Brazil (Casali & Couto, 1984). The genus has, approximately, 33 species, considering the domesticated, semi-domesticated and wild ones. It is important to mention that new species have been described as they have been obtained in collecting expeditions (Pickersgill, 1971; Bosland, 1993, Oyama *et al*., 2006).

Capsicum has been cultivated and commercialized in the tropical region of Latin America (Nuez *et al*., 1996). The genus is used as spice, giving taste and flavor to a variety of dishes in several typical cuisines around the world, due to some important traits of this plant like appearance, texture, color, flavor, vitamin content and pungency (Moore, 1970). Because of different ecological, cultural and technological conditions these species were subjected many changes could be noticed, leading to a generalization that the variability is higher in the part of the plant which is economically important (Pickersgill, 1971; Oyama *et al*., 2006).

In Brazil, the cultivation and commercialization of chili and peppers have been increasing in the latest years. However, reliable statistics data on *Caspicum* production are rare, according to Ribeiro *et al.* (2008). According to these authors, 348 million tons of chili and peppers were produced in 12 thousand ha, of them, 5 thousand ha were cultivated with sweet and hot pepper, with annual production of 75 million tons, being the main producers the States of Minas Gerais, São Paulo and Rio Grande do Sul (Panorama Rural, 2006; Ribeiro *et al.*, 2008).

In the Amazon, the cultivation of chili is one important source of income for the local agricultural population (indians and non-indians) due to the fact that this region is an important center of domesticated species of *Capsicum* (Costa *et al*., 2009). The four species of *Capsicum* cultivated in Brazil are also grown in Roraima where the cultivation and commercialization of chili and peppers have been increasing a lot. The morphotypes like "malagueta" (*C. frutescens*), "murupi" (*C. chinense*) and "olho de peixe" (*C. chinense*) are the most commercialized in indian and non-indian communities (Barbosa *et al*., 2002), as well as in the northeast and southeast regions of Brazil (Lannes *et al*., 2007).

The growing domestic demand, about R$ 80 million a year, has increased the yield of the cultivated area and the establishment of agro-industries, becoming the agrobusiness of Capsicum one of the most important in Brazil (Ribeiro *et al*., 2003; Panorama Rural, 2006).

It is important to point out that wide knowledge on production and commercialization is necessary to enhance the progress in breeding programs of cultivated and wild species (Buso *et al*., 2003; Rêgo *et al*., 2010). Several authors have highlighted the importance of studies on the characterization of *Capsium* germplasm, as well as its diversity, in order to make them available to researchers (Geleta *et al*., 2005; Sudré *et al*., 2005; Oyama *et al*., 2006; Bento *et al*., 2007; Fonseca *et al*., 2008; Rêgo *et al*., 2009; Thul *et al*., 2009; Rêgo *et al*., 2010). In this context, it is necessary to carry out studies aiming the understanding of the local culture, the increase of production, disease resistance and tolerance to adverse environments, among other biotic and abiotic factors that can affect the yield (Oliveira *et al*., 2003).

The Universidade Federal de Roraima has one Germplasm Bank where a number of *Capsicum* accessions are stored. The characterization of those accessions is necessary in order to provide better utilization of these genetic resources in breeding programs. Also to avoid duplicated accessions in the Germplasm banks, appropriate studies are necessary. This point is the one which takes a higher consumption of time and resources available for the researchers (Carvalho *et al*., 1999).

This work aimed to evaluate 69 *Capsicum* accessions from the Germplasm Bank of the Universidade Federal de Roraima (UFRR), for some fruit quality traits, for future breeding program.

MATERIAL AND METHODS

In 2002, seeds of 69 accessions of *Capsicum* genus (Table 1), obtained from the Germplasm Bank of the Universidade Federal de Roraima (UFRR), were sown on expanded polystyrene trays with 128 cells. The transplanting of the seedlings to the experimental field in Cauamé Campus, of the UFRR, located in Boa Vista, Roraima State, was done, in March, at 60 days after sown. The evaluations were carried out from May to December, 2002, when all the plants showed ripe fruits.

The experiment was carried out in a randomized block design, with 69 treatments, three replications and 10 plants per plot, with a total of 30 plants per accession, spaced 1.0 x 1.0 m among rows and plants. The cultural management was carried out according to Filgueira (2000).

The descriptors used were proposed for *Capsicum* in 1995 by IPGRI (International Plant Genetic Resources Institute, renamed Biodiversity International). To obtain good morphological traits for each accession, the average of 10 randomized replications was taken, as the fruits got ripe.

The following traits were evaluated: pedicel length, fruit length, fruit width, fruit wall thickness, number of locules, seed yield per fruit, 100 seeds weight, fruit fresh weight, dry matter, dry matter content, pungency and color of ripe fruit.

Vitamin C content (Vit. C) and pH (pH) were obtained using 3.0-10.0 g of the tissue (pericarp and pulp) in which were added 100 mL of distilled water, proceeding to homogenization. The homogenized was used to determine the pH. After pH evaluation, 10 mL of sulfuric acid 20%, 1 mL of 0.01 N potassium iodide, 1 mL of 1% starch were added to the homogenized, titrating with 0.01 N potassium iodate, according to Pregnolatto & Pregnolatto (1985). The vitamin C content was determined by the expression:

Vitamin C (mg/g)= (100 x V x F)/P, where:

V= volume of potassium iodate spent in titration (mL); F= correction factor (0.8806 mg of vitamin C); P= weight of fresh sample (g).

The analysis of the total soluble solids (SST) of the fruit was carried out using tissues of pericarp and pulp, which were crushed with pestle and mortar to obtain one drop of juice which was taken to table refractometer, where the percentage of SST was evaluated.

Quantitative traits values were subjected to analysis of variance, through the F test at 1% followed by the grouping of the average values of the accessions through the Scott-Knott test at 1%. The statistic analyses were carried out through the GENES software (Cruz, 2001).

We determined the qualitative traits: color of ripe fruit (IPGRI, 1995) and the pungency of the fruit, classified through the sensorial method into the following classes: MA (very high), A (high), M (medium) and B (low) (Barbosa *et al*., 2002).

RESULTS AND DISCUSSION

A very highly significant difference ($p<0.01$) was found among treatments for the studied quantitative parameters (Table 2), showing a great variability among the accessions stored in the Germplasm Bank of the UFRR. The genetic variability has been reported in different species of *Capsicum* genus in recent studies (Geleta *et al*., 2005; Sudré *et al*., 2005; Oyama *et al*., 2006; Bento *et al*., 2007; Fonseca *et al*., 2008; Rêgo *et*

Table 1. *Capsicum* accessions, their local and year of collection (acessos pertencentes às espécies do gênero *Capsicum*, com seus respectivos local e ano de coleta). Boa Vista, UFRR, 2002.

Accessions	Species	Collection site	Accessions	Species	Collection site
01	C. annuum	Boa Vista-RR	42	*C. chinense*	Iracema-RR
03	C. chinense	Boa Vista-RR	43	*C. annuum*	Boa Vista-RR
04	C. frutescens	Tepequém-RR	44	*C. frutescens*	Tepequém-RR
05	C. chinense	Boa Vista-RR	45	*C. annuum*	Viçosa-MG
06	*C. baccatum*	Iracema-RR	47	*C. frutescens*	Tepequém-RR
07	C. chinense	Iracema-RR	48	*C. annuum*	Boa Vista-RR
08	C. chinense	Iracema-RR	49	*C. chinense*	Boa Vista-RR
09	*C. chinense*	Alto Alegre-RR	50	*C. chinense*	Boa Vista-RR
10	C. chinense	Boa Vista-RR	51	*C. chinense*	Boa Vista-RR
11	C. chinense	Boa Vista-RR	52	*C. chinense*	Tepequém-RR
12	C. baccatum	Viçosa-MG	53	*C. chinense*	Boa Vista-RR
15	C. chinense	Boa Vista-RR	54	*C. chinense*	Boa Vista-RR
19	*C. annuum*	Boa Vista-RR	55	*C. chinense*	Boa Vista-RR
20	C. baccatum	Viçosa-MG	56	*C. chinense*	Boa Vista-RR
21	*C. baccatum*	Viçosa-MG	57	*C. chinense*	Boa Vista-RR
22	*C. chinenese*	Tepequém-RR	58	*C. chinense*	Boa Vista-RR
23	*C. chinense*	Boa Vista-RR	59	*C. chinense*	Boa Vista-RR
24	*C. frutescens*	Baixo R. Branco-RR	60	*C. chinense*	Boa Vista-RR
25	*C. frutescens*	Iracema-RR	61	*C. chinense*	Boa Vista-RR
26	*C. chinense*	Iracema-RR	62	*C. chinense*	Boa Vista-RR
27	*C. chinense*	Boa Vista-RR	63	*C. chinense*	Boa Vista-RR
28	*C. frutescens*	Tepequém-RR	64	*C. chinense*	Boa Vista-RR
29	*C. chinense*	Tepequém-RR	65	*C. chinense*	Boa Vista-RR
30	*C. frutescens*	Tepequém-RR	66	*C. chinense*	Boa Vista-RR
31	*C. chinense*	Boa Vista-RR	67	*C. chinense*	Boa Vista-RR
32	*C. chinense*	Boa Vista-RR	68	*C. chinense*	Boa Vista-RR
33	*C. frutescens*	Tepequém-RR	69	*C. baccatum*	Viçosa-MG
34	*C. chinense*	Boa Vista-RR	70	*C. baccatum*	Viçosa-MG
35	*C. chinense*	Apiaú-RR	71	*C. chinense*	Boa Vista-RR
36	*C. chinense*	Boa Vista-RR	72	*C. frutescens*	Tepequém-RR
37	*C. chinense*	Boa Vista-RR	73	*C. chinense*	Boa Vista-RR
38	*C. chinense*	Boa Vista-RR	74	*C. baccatum*	Viçosa-MG
39	*C. chinense*	Boa Vista-RR	75	*C. chinense*	Boa Vista-RR
40	*C. chinense*	Iracema-RR	76	*C. chinense*	Boa Vista-RR
41	*C. frutescens*	Boa Vista-RR			

al., 2009; Thul *et al*., 2009; Rêgo *et al*., 2010). The coefficient of variation (CV) for fruit parameters was low to average, except for pedicel length, fruit fresh weight and minor fruit width, which showed high coefficients according to the classification of Silva *et al*. (2011a). Nevertheless, the differences among the accessions could be detected, showing the great variability among them in comparison to the environmental variation (experimental error). There is a possibility that these variables have been affected by the size of the samples, which, according to Silva *et al*. (2011b), should be of 15 fruits for the evaluation of these parameters. However, the size of the sample did not make any difference for the coefficient of variation for fruit wall thickness.

The accession 48 showed major values for the following parameters: fruit length, major fruit width and fresh matter (Table 2). However, this first trait did not differ statistically among the accessions 06, 12 and 50. This fact may have happened because this accession belongs to *C. annuum* species, which presents mostly sweet peppers, which presents higher weight and bigger fruits. Rêgo *et al*. (2001; 2009) point out the importance of these traits as secondary components of the

Table 2. Means of morphological characters of 69 accessions of *Capsicum* spp (médias de características morfológicas em 69 acessos de *Capsicum* spp.). Boa Vista. UFRR. 2002.

Accession	CF	EP	CP (cm)	MADF	MEDF	MF	PCS (g)	MS	NSF	NL
01	1.64f	0.13b	2.15d	1.14g	0.81d	0.89f	0.73b	0.51d	8.00d	2.330b
03	6.43c	0.10b	2.50d	1.40g	0.17e	3.54e	0.91a	0.47d	38.00c	3.00b
04	5.72d	0.24b	3.06c	2.33e	1.30c	7.01d	0.55c	0.74c	31.00d	3.33a
05	6.20c	0.17b	3.94b	2.46e	0.67d	8.45d	0.52c	0.57c	34.00c	3.33a
06	9.16a	0.20b	4.74a	1.70f	0.20e	7.85d	0.77b	1.02c	43.00c	3.00b
07	3.84e	0.14b	2.74c	1.30g	0.57d	1.86f	0.40d	0.21d	28.33d	3.00b
08	4.06e	0.22b	2.63c	1.17g	0.57d	2.01f	0.37d	0.24d	31.00d	3.66a
09	3.81e	0.11b	2.07d	2.80d	1.57c	8.09d	0.61c	0.61c	43.33c	3.66a
10	6.18c	0.14b	2.27d	2.07f	0.57d	6.07d	0.56c	0.43d	30.33d	3.00b
11	5.69d	0.14b	4.07b	2.04f	1.03c	6.20d	0.68b	0.78c	25.00d	3.00d
12	9.60a	0.21b	5.13a	2.00f	0.30e	13.83b	1.19a	1.46b	35.00c	3.00b
15	3.33e	0.26b	4.51a	3.48c	2.20a	9.82c	0.78b	0.72c	42.00c	3.33a
19	5.56d	0.14b	5.03a	1.70f	0.18e	4.73e	1.02a	0.60c	10.00d	3.00b
20	3.47e	0.10b	3.02c	0.88h	0.31e	0.97f	0.22d	0.28d	24.33d	3.33a
21	6.06c	0.21b	4.96a	3.06d	0.61d	13.92b	0.79b	2.18a	124.66a	3.00b
22	2.45f	0.21b	2.81c	3.01d	2.17a	7.64d	0.62c	0.69c	33.33c	4.00a
23	6.10c	0.17b	3.56b	2.33e	0.41e	8.09d	0.80b	0.60c	36.33c	2.66b
24	3.40e	0.10b	3.36c	0.80h	0.26e	1.01f	0.77b	0.30d	28.00d	3.00b
25	1.46f	0.10b	2.13d	1.34g	0.97c	1.19f	0.18d	0.21d	43.00c	3.00b
26	1.76f	0.14b	1.90d	1.03g	0.47e	0.72f	0.54c	0.13d	19.00d	2.66b
27	5.93c	0.16b	4.60a	2.81d	0.30e	10.18c	0.92a	2.36a	113.33a	3.33a
28	1.68f	0.27b	1.84d	1.85f	1.26e	2.25f	0.33d	0.25d	11.00d	3.33a
29	6.00c	0.22b	2.76c	1.80f	0.47e	6.83d	0.66b	0.65c	20.33d	3.66a
30	3.23e	0.11b	2.93c	3.00d	1.11c	8.12d	0.69b	0.84c	71.00b	3.00b
31	3.77e	0.14b	3.16c	2.18e	1.42c	6.80d	0.64b	0.81c	30.66d	3.33a
32	6.14c	0.10b	3.34c	1.11g	0.14e	2.17f	0.77b	0.37d	18.00d	2.33b
33	1.23f	0.10b	1.73d	0.50h	0.27e	0.17f	0.72b	0.11d	13.88d	2.00b
34	1.96f	1.30a	2.10d	1.76f	1.19c	2.3f	0.45c	0.30d	28.33d	3.00b
35	5.20d	0.13b	4.13b	2.16e	0.82d	6.61d	0.49c	0.27d	50.66c	3.00b
36	8.72b	0.27b	4.08b	2.42e	0.38e	12.49b	0.29d	2.17a	75.33b	3.00b
37	8.72b	0.27b	4.08b	2.42e	0.38e	12.49b	0.29d	2.17a	75.33b	3.00b
38	3.90e	1.18a	3.86b	2.26e	0.27e	5.05e	0.91a	0.71c	19.33d	3.00b
39	6.32c	0.20b	2.95c	1.45g	0.79d	6.90d	0.57c	0.37d	33.00c	2.33b
40	6.61c	0.17b	4.23b	2.53e	0.60d	8.80d	0.55c	0.52d	41.33c	3.00b
41	3.03e	0.10b	2.70c	0.56h	0.17e	0.56f	0.41d	0.18d	28.33d	3.00b
42	3.76e	0.14b	4.17b	3.00d	1.30c	0.26f	0.45c	0.75c	32.66c	3.00b
43	1.84f	0.13b	1.74d	1.44g	0.68d	1.22f	0.71b	0.30d	24.00d	2.33b
44	2.57f	0.10b	2.20d	0.56h	0.23e	0.43f	0.58c	0.15d	22.66d	2.33b
45	7.94b	0.15b	5.94a	2.00f	0.25e	0.18f	0.76b	2.09a	21.66d	2.66b
47	4.93d	0.14b	3.14c	2.70d	1.27c	10.59c	0.68b	0.65c	40.66c	3.66a
48	10.41a	0.34b	3.52b	5.50a	1.70b	58.96a	0.73b	0.51d	144.33a	3.66a
49	5.60d	0.17b	4.64a	2.76d	0.41e	9.19d	1.05a	1.67b	74.33b	3.00b
50	9.80a	0.17b	5.90a	2.13e	0.34e	11.08c	0.68b	2.22a	21.33d	3.33a
51	5.20d	0.11b	2.92c	2.43e	0.98c	6.39d	0.36d	0.91c	41.00c	3.33a
52	2.20f	0.15b	2.13d	2.57e	1.63b	5.15e	0.63b	0.50d	24.66d	4.00a
53	5.60d	0.10b	3.66b	1.93f	0.43e	4.44e	0.76b	2.19a	59.66c	3.00b
54	3.74e	0.20b	4.00b	3.67c	1.51c	11.09c	0.81b	1.03c	58.33c	3.66a
55	3.94e	0.10b	2.90c	1.44g	0.54d	2.01f	0.53c	0.23d	11.33d	3.00b
56	5.90c	0.15b	3.37c	1.87f	0.44e	5.52e	0.85b	0.51d	21.33d	2.66b
57	6.53c	0.11b	2.40d	2.16e	0.34e	7.48d	0.56c	0.88c	48.00c	3.33a
58	3.54e	0.12b	3.60b	1.16g	0.27e	1.60f	0.65b	0.27d	22.66d	2.66b
59	6.46c	0.11b	3.46b	1.50f	0.30e	4.68e	0.54c	1.07c	38.33c	2.66b
60	3.30e	0.14b	2.16d	2.93d	1.66b	7.47d	0.49c	0.55c	41.33c	3.33a
61	4.34e	0.28b	4.24b	2.84d	1.36c	10.54c	1.66a	1.54b	66.00b	3.00b
62	5.22d	0.04b	2.88c	1.79f	1.15c	5.31e	0.34d	0.47d	25.66d	3.00b
63	5.04d	0.18b	3.17c	2.69d	1.14c	6.44d	0.69b	0.98c	28.00d	3.33a
64	3.36e	0.17b	2.00d	2.00f	0.93d	4.55e	0.54c	0.54d	40.33c	3.33a
65	6.98c	0.15b	2.71c	2.16e	0.58d	7.62d	0.75b	0.61c	18.66d	3.00b
66	6.73c	0.18b	3.50b	2.54e	0.68d	8.93d	0.59c	0.52c	44.00c	3.66a
67	5.18d	0.13b	3.56b	2.21e	1.48c	6.57d	0.68b	0.75c	42.66c	4.00a
68	4.87d	0.10b	3.26c	1.31g	0.53d	3.29e	0.68b	0.31d	21.00d	2.66b
69	3.78e	0.36b	3.53b	4.20b	2.17a	13.42b	0.44c	2.53a	61.00c	3.66a
70	7.66b	0.18b	4.47a	2.43e	0.21e	11.12c	0.85b	2.59a	92.66b	2.66b
71	5.72d	0.25b	3.86b	2.70d	1.53c	8.65d	0.66b	0.60c	38.00c	3.33a
72	1.81f	0.10b	2.71c	1.08g	0.44e	0.93f	0.46c	0.16d	26.66d	2.66b
73	6.83c	0.10b	2.93c	1.36g	0.20e	3.22e	0.75b	0.87c	18.33d	2.00b
74	5.07d	0.22b	5.33a	1.83f	0.66d	6.62d	0.57c	1.03c	31.00d	3.00b
75	3.10e	0.10b	3.30c	3.24d	1.76b	7.93d	0.82b	0.79c	48.66c	3.33a
76	2.12f	0.13b	1.88d	2.36e	1.47c	5.48e	0.66b	0.38d	24.00d	3.66a
CV (%)	14.31	13.75	17.7	12.42	29.08	26.10	21.18	27.82	35.74	15.45

CF= fruit length; EP= fruit wall thickness; CP= pedicel length; MADF= major fruit width; MEDF= minor fruit width; MF= fruit weight; PCS= 100 seeds weight; MS= fruit dry matter; NSF= seed yield/fruit; NL= locule number; Means followed by the same letter. at column. belong to the same group by Scott-Knott criteria ($p \leq 0.01$) (CF= comprimento do fruto; EP= espessura do pericarpo; CP= comprimento do pedúnculo; MADF= maior diâmetro do fruto; MEDF= menor diâmetro do fruto; MF= matéria fresca do fruto; PCS= peso de 100 sementes; MS= matéria seca; NSF= número de sementes por frutos; NL= número de lóculos; Médias seguidas de uma mesma letra. na coluna. pertencem a um mesmo grupo. pelo critério de Scott Knott a 1% de probabilidade).

Table 3. Means of chemical characters of 69 accessions of *Capsicum* spp. (média de características químicas em 69 acessos de *Capsicum* spp.) Boa Vista, UFRR, 2002.

Accession	pH	Vit. C (mg/g)	SST (%)	TMS (%)	Accession	pH	Vit.C (mg/g)	SST (%)	TMS (%)
01	4.99b	76.17d	12.66b	29.71b	43	5.50a	123.21c	12.66b	23.31c
03	5.49a	110.40c	9.16c	13.54e	44	5.53a	109.25c	16.00a	36.17a
04	5.52a	74.69d	7.66d	6.91e	45	5.45a	112.00c	12.50b	17.72d
05	5.49a	45.53e	5.41d	6.75e	47	4.36b	101.59c	7.08c	12.58e
06	5.47a	92.57c	10.75b	18.70d	48	6.23a	16.38e	5.16d	6.28e
07	5.74a	89.14c	7.25d	12.76e	49	5.60a	73.74d	10.75b	34.02b
08	5.91a	104.49c	7.08d	12.11e	50	5.43a	95.25c	9.75c	24.54c
09	4.55b	84.55d	7.91c	11.50e	51	5.42a	159.64b	7.50d	10.81e
10	5.39a	83.67d	7.08d	7.80e	52	5.41a	103.38c	7.08d	14.98d
11	5.30a	69.62d	6.58d	8.37e	53	5.46a	59.28d	16.16a	34.97b
12	5.55a	115.40c	11.91b	17.74d	54	5.75a	59.89d	7.00d	10.28e
15	4.72b	97.36c	8.16c	10.52e	55	5.23a	16.08e	9.33c	15.06d
19	5.43a	52.29e	11.58b	15.63d	56	5.06b	132.11b	7.00d	10.63e
20	5.29a	38.08e	11.50b	21.10d	57	5.45a	99.15c	8.16c	10.64e
21	5.51a	52.29e	11.58b	19.17d	58	4.50b	110.12c	8.50c	18.84d
22	5.35a	119.19c	6.83d	9.21e	59	5.33a	102.50c	14.66a	23.90c
23	5.50a	115.85c	6.91d	8.52e	60	3.38c	97.53c	9.08c	10.39e
24	5.63a	77.75d	12.00b	31.80b	61	5.38a	55.97e	8.33c	17.00d
25	5.51a	135.20b	12.91b	20.67d	62	5.36a	37.91e	8.00c	7.73e
26	5.78a	106.25c	6.83d	14.51d	63	5.57a	115.15c	7.58d	11.37e
27	5.44a	65.39d	11.70b	31.46b	64	5.42a	119.86c	7.41d	10.28e
28	4.75b	143.43b	8.50c	11.08e	65	5.60a	120.42c	7.58d	11.45e
29	5.55a	115.96c	6.08d	11.35e	66	5.73a	82.80d	6.66d	7.99e
30	5.36a	145.25b	8.58c	13.52e	67	5.41a	138.06b	7.83c	11.29e
31	5.45a	25.43e	6.48d	12.39e	68	5.33a	123.48c	8.08c	12.09e
32	5.73a	83.99d	7.75d	12.14e	69	5.46a	61.99d	10.08c	15.85d
33	5.32a	191.39a	14.83a	51.92a	70	5.38a	80.96d	10.00c	17.42d
34	5.60a	130.18b	8.80c	12.85e	71	4.79b	100.39c	6.50d	8.88e
35	5.46a	50.52e	6.83d	6.91e	72	5.19a	116.09c	12.66b	21.32d
36	5.56a	52.72e	7.25d	10.37e	73	5.20a	20.76e	7.25d	29.41b
37	5.72a	79.93d	7.66d	17.73d	74	5.05b	74.02d	11.75b	14.75d
40	5.53a	32.20e	12.41b	18.50d	75	5.70a	94.31c	6.66d	10.75e
41	5.45a	116.64c	14.33a	44.03a	76	5.30a	82.23d	7.16d	8.43e
42	5.30a	124.04c	7.41d	12.50e					

pH= hidrogenionic potential; Vit. C= vitamin C; SST= total soluble solids; TMS= dry matter content (pH= potencial hidrogeniônico; Vit. C= vitamina C; SST= sólidos solúveis totais; TMS= teor de matéria seca).

production. According to these studies, it is possible to indirectly select more productive plants by selecting these components. The dry matter content is oppositely related to the fruit weight, so the longer is the fruit, the lower is its dry matter content (Casali & Stringheta, 1984; Lannes *et al*., 2007; Rêgo *et al*., 2010). The results of this study, concerning fruit length and dry matter content, are in agreement with these authors since the accession 48 (*C. annuum*) showed the highest number for fruit length, 10.41 cm (Table 2), and one of the lowest numbers for dry matter content, 6.28 g, among the studied accessions (Table 3).

The accessions 15, 22 and 69 showed the highest values for the minor fruit width, 2.20; 2.17 and 2.17, respectively, forming a separated group. Sudré *et al*., (2005) emphasize the importance of measuring the fruit width in genetic diversity studies in *Capsicum*.

The fruit wall thickness values ranged from 0.04 to 1.3 cm (Table 2) and the accessions 38 and 34 showed

Table 4. Fruit mature color: red (V), yellow (A) and orange (L) and pungency: very high (MA), high (A), mean (M) and low (B), of 69 accessions of the Vegetable Germplasm Bank of Universidade Federal de Roraima (cor do fruto maduro: vermelha (V), amarela (A) e laranja (L) e teor de pungência: muito alta (MA), alta (A), média (M) e baixa (B), em 69 acessos pertencentes ao Banco de Germoplasma de Hortaliças da Universidade Federal de Roraima). Boa Vista, UFRR, 2002.

Accession	Color of ripe fruits	Pungency level	Accession	Color of ripe fruits	Pungency level
01	V	A	41	V	MA
03	A	MA	42	L	MA
04	V	MA	43	V	A
05	V	B	44	V	MA
06	V	A	45	V	B
07	V	MA	47	V	MA
08	A	MA	48	V	B
09	V	MA	49	V	A
10	V	B	50	V	MA
11	V	M	51	V	MA
12	V	A	52	V	M
15	A	MA	53	V	M
19	V	A	54	V	M
20	V	A	55	L	MA
21	V	M	56	V	B
22	V	A	57	V	B
23	V	M	58	A	MA
24	L	MA	59	V	A
25	A	MA	60	V	MA
26	A	A	61	V	A
27	V	A	62	V	M
28	A	A	63	V	B
29	V	A	64	V	B
30	V	M	65	V	M
31	V	MA	66	V	M
32	L	MA	67	V	MA
33	V	MA	68	V	MA
34	L	A	69	V	A
35	V	B	70	V	A
36	A	M	71	V	A
37	L	MA	72	V	MA
38	V	B	73	V	A
39	V	M	74	V	MA
40	V	MA	75	V	B

the highest values, 1.18 and 1.3 cm, respectively. Casali *et al*. (1984) found that the increase of fruit wall thickness is related to the reduction of the yield of dry matter. According to the authors, accumulation of water can occur in the cells of the surface tissues inner to the fruit pulp. On the other hand, pericarp thickness was positively related to dry matter in *C. baccatum* (Rêgo *et al*., 2001). In accordance to Rêgo *et al*. (2001) this trait is directly related to the yield of *C. baccatum*. Recent researches showed that this trait is controlled by non-additive genes, allowing the development of hybrids (Rêgo *et al*., 2009). Lannes *et al*. (2007) on studies with *C. chinense* reported a positive relation between fruit weight and fruit wall thickness, showing the importance of this trait on the development of varieties for the fresh market, once fruits with thicker pericarp are more resistant to damage in postharvest management and transportation. Rêgo *et al.* (2009) suggest plant breeding through simple selection for these variables, once they are determined by genetic additive effects.

Pedicel length ranged between 1.73 and 5.94 cm. Several accessions were included in the group with the higher values (from 4.47 to 5.94 cm), in contrast to the group that showed the lower values (from 1.73 to 2.50 cm). In the process of obtaining pepper powder, the flavor of the final product may be changed if during the milling process, calyx and pedicel were added (Casali & Stringheta, 1984).

A variation of two to four locules was noticed among the evaluated accessions. The accessions 22, 52 and 67, of *C. chinense* species (Table 1) showed the highest number of locules (Table 3). According to Casali *et al*. (1984), the number of the locules is related to the increase in the number of seeds per fruit. In tomatoes, the genes which control the shape of the fruit, obtained by the ratio between length and width, also control the number of locules. However, this correlation was not observed for the fruit of *Capsicum* genus (Paran & Van der Knapp, 2007).

The average seed yield per fruit ranged between 8.00 and 144.33. The accessions 21, 27 and 48 showed the highest number of seeds, with 124.66, 113.33 and 144.33 seeds, respectively (Table 2). The results presented in this study are not in agreement with those ones reported by Casali *et al*. (1984), since the accessions 22, 52 and 67, which showed the highest number of locules, were not the same which showed the highest seed yield per fruit. This variable is important to determine the variability among accessions and it should be determined in characterization works (Rêgo *et al*., 2003; Bento *et al*., 2007).

The accessions 03, 12, 19, 27, 38,

49 and 61 showed the highest 100 seeds weight, ranging between 0.91 and 1.66 g. The other accessions were set in three different groups (Table 2). The accessions 21, 27 and 48 which showed the highest number of seeds, mentioned in the previous paragraph, sometimes do not show the heaviest seeds.

The highest contents of total soluble solids (SST) were observed in the accessions 33, 41, 59, 44 and 53, presenting 14.83; 14.33; 14.66; 16.00 and 16.16, respectively (Table 3). According to Lannes *et al*. (2007), the higher SST content, the lower the water content in fruit. Because of this fact, this trait is very important in *Capsicum* breeding aiming industrial use, as the cost for dehydration of the fruit will be lower. Hybridization can be a viable strategy to increase SST content, as non-additive genes are predominant in its determination (Rêgo *et al*., 2009).

The accession 33, which belongs to *C. frutescens* species, better known as "malagueta", showed the highest vitamin C content, 191.39 mg/g (Table 3). According to Lantz (1946), ascorbic acid content (vitamin C) decreases 30%, approximately, in pickled and cooked peppers, and it reaches almost 0% in dry peppers.

The average pH ranged between 3.38 and 6.23. The highest and the lowest pH were obtained from the accessions 60 (*C. chinense*) and 48 (*C. annuum*), respectively (Table 3). It is important to evaluate pH in order to set the best day for harvest, since it is related to an appropriate composition for fresh market, for this, pH should be 5.0-5.2. The value of pH reaches its record, 6.52, in green immature fruit and tends to decrease as the fruit gets ripe, showing values of 5.02 in the mature fruit (Cochran, 1964).

The accessions 33, 41 and 44 showed 51.92; 44.03 and 36.17% of dry matter content, respectively (Table 3). This trait is important for breeding *Capsicum* for industry, since the higher dry matter content per fruit, the higher the yield in the use of dry or powder of chili and peppers (Lannes *et al*., 2007).

The colors of ripe fruit were red, yellow and orange (Table 4). The red color of ripe fruits was observed in 55 accessions (79.71%). Little color variability was observed in comparison to Inoue & Reifschneider (1989) in which orange, yellow, orange green, light yellow, brown, orange brown and dark red were observed.

For pungency, among 69 studied accession, 26 of them were classified as "very high" (37.68%), 19 as "high" (27.54%), 13 as "average" (18.84%) and 11 as "low" (15.94%) (Table 4).

Barbosa *et al*. (2002), describing 163 *Capsicum* accessions from the Bank of Germoplasm of *Capsicum* of Embrapa in Roraima, noticed similar results for the colors for ripe fruit and levels of pungency, for which red color and the levels "high" and "very high" for pungency were the most frequent. Pungency and color, however, are not correlated characteristics, since it is possible to have peppers in different colors and no pungency and different levels of pungency in the same color (Table 4).

The obtained results showed that there is a great variability among the 69 accessions, both for morphological and chemical parameters of the fruit. This diversity can be used in *Capsicum* breeding programs. In order to obtain cultivars for higher powder yield, accessions 33, 41 and 44 are recommended, since they recorded high dry matter and total soluble solids contents. In order to obtain higher marketable yield (for fresh market), accession 48 is recommended, which showed the highest values for fresh matter, fruit length and fruit width, and accession 33, *Capsicum frutescens*, which showed the highest vitamin C content.

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