

Research Article

QUANTIFYING THE QUALITY ATTRIBUTES CAPSAICIN AND OLEORESIN CONTENT IN VARIOUS HYBRIDS OF CHILI PEPPERS (*CAPSICUM ANNUUM L.*) AFFLICTED BY ANTHRACNOSE DISEASE ACROSS DIFFERENT SEASONS

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ABSTRACT

Chili (*Capsicum annum L.*) stands as a crucial spice in both its ripe, dried form and its fresh, green form, widely used in kitchens worldwide. Its pungency and vibrant red color make it an indispensable condiment in various cuisines. However, anthracnose disease poses a significant threat to chili crops, causing substantial quantitative and qualitative damage. The severity of this disease fluctuates due to factors such as weather conditions, plant growth stages, and varying cultivar susceptibilities, leading to changing disease dynamics over time. To address this issue, research is imperative to understand the impact of seasonal variations and anthracnose disease incidence on quality parameters like capsaicin and oleoresin content. Thus, a study was conducted, assessing three resistant hybrids and nine moderately resistant hybrids alongside their parent varieties and a susceptible check, CHD8. This evaluation took place across three distinct planting seasons: February, June, and September. In the resistant hybrids, it was observed that the capsaicin and oleoresin content was higher in healthy fruits compared to those affected by anthracnose disease. Moreover, hybrids exhibited higher capsaicin content than their parent varieties across all three seasons. Therefore, selecting healthy fruits from disease-free hybrids is recommended to achieve higher yields of capsaicin and oleoresin in chili.

Keywords: Chilli, Hybrids, Quantification of Quality Parameters, Capsaicin and Oleoresin, Anthracnose Affected Fruits.

INTRODUCTION

Chili (*Capsicum annum L.*) holds a unique position in the human diet, being consumed worldwide in both its ripe, dried form (as a spice) and its green fruits (as a vegetable). It serves as a vital condiment in culinary applications, prized for its pungency and vibrant red color. Additionally, fresh chili fruits are a rich source of vitamins A, C, and E. The pungent compound in chili, capsaicin, exhibits various effects on the body, including anti-inflammatory, anti-obesity, and desensitization against different chemical analgesic effects. Capsaicin has the potential to lower blood cholesterol levels and may be utilized as an anti-obesity agent. Furthermore, Vitamin P, a group of plant compounds known as flavonoids or bioflavonoids, extracted from chili, has the ability to prevent heart attacks by dilating the blood vessels.

India ranks first in chili cultivation worldwide; however, its productivity in dry chili is notably low, approximately 0.9t/ha, compared to the global average of approximately 2.0 t/ha. Studies by Malathi *et al.*, (2022) in Salem District and Rajamanickam (2020) have highlighted that certain chili hybrids, such as TNAU Chilli hybrid CO1 and Arka Saanvi, exhibit higher fruit yield and pungency. Similarly, hybrids like TNAU CO (Ch) 1, Arka Harita, and Arka Meghana have shown superior yields compared to local chili varieties in Ramnathapuram Condition. Pest and diseases account for about 30 percent reduction in marketable fruit yield, with anthracnose disease being particularly detrimental. This seed-borne pathogen causes significant quantitative

and qualitative damage to chili crops. The severity of anthracnose disease varies based on weather conditions, plant growth stages, and cultivar susceptibilities, leading to dynamic changes in disease prevalence over time.

To address these challenges, there is a pressing need for research to investigate the impact of seasonal variations and anthracnose disease incidence on the quality parameters, such as capsaicin and oleoresin content, in both healthy and anthracnose-infected chili fruits of hybrids and their parent varieties with a susceptible checks.

MATERIALS AND METHODS

A research study was conducted at the Department of Vegetable Crops, HC & RI, TNAU, Coimbatore, to investigate the capsaicin and oleoresin content of chili fruits affected by anthracnose disease. For this study, twelve hybrids were selected, comprising three resistant hybrids and nine moderately resistant hybrids (refer to Table 1). Previously, Ruth Beulah Rani (2002) identified certain hybrids as anthracnose-resistant, such as S1 x Ujwala, S2 x CC-4, and CC-4 x S2, while others, like Ujwala x S2, KDC 1 x S2, Pepper Hot x S2, Ujwala x S1, Pepper Hot x S1, CC-4 x S1, S1 x CC-4, S2 x Arka Lohit, and S2 x Pepper Hot, were found to be moderately resistant. These twelve hybrids, along with their parent varieties and a susceptible check, CHD8, were evaluated across three different planting seasons: February (Season I), June (Season II), and September (Season III).

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Table 1. Different resistant and moderately resistant hybrids and parents of chilli

Resistant Hybrids	Moderately resistant hybrids	Parents	Susceptible chelk
S1 x Ujwala	Ujwala x S2	S1	CHD 8
S2 x CC-4	KDC 1 x S2	S2	
CC-4 x S2	Pepper Hot x S2	CC-4	
	Ujwala x S1	Ujwala	
	Pepper Hot x S1	KDC 1	
	CC-4 x S1	Pepper Hot	
	S1 x CC-4	Arka Lohit	
	S2 x Arka Lohit		
	S2 x Pepper Hot		

The fruit samples, comprising both healthy and capsaicin-infected fruits, were utilized to quantify quality parameters such as capsaicin and oleoresin content across three different seasons. The capsaicin content of dried chilli fruits was determined following the procedure outlined by Quagliotti (1971) and expressed as grams per 100 grams of fruits or as a percentage. The oleoresin content was analyzed according to the method described by Mathai (1988). Firstly, the oven-dried fruits were powdered, and a 5g sample was placed in a glass column of a Soxhlet apparatus. Oleoresin was then extracted using acetone as the organic solvent. The resulting extract was evaporated in a steam bath, heated for 30 minutes in an oven at 60°C, cooled, weighed, and the content was expressed as a percentage.

RESULTS AND DISCUSSION

Table 2. Capsaicin content of hybrids and parents of chilli in healthy and infected fruits

Hybrids / Parents	Capsaicin content in healthy fruits (%)				Capsaicin content in infected fruits (%)			
	I Season	II Season	III Season	Average	I Season	II Season	III Season	Average
S1 x Ujwala	0.78	0.75	0.76	0.77	0.70	0.68	0.67	0.68
S1 x CC-4	0.71	0.72	0.73	0.72	0.65	0.66	0.66	0.66
S2 x CC-4	0.69	0.70	0.70	0.70	0.60	0.62	0.61	0.61
S2 x Arka Lohit	0.59	0.56	0.58	0.57	0.50	0.48	0.51	0.50
S2 x Pepper Hot	0.69	0.70	0.71	0.70	0.55	0.60	0.62	0.59
Ujwala x S1	0.66	0.62	0.63	0.63	0.56	0.59	0.58	0.58
Ujwala x S2	0.67	0.64	0.65	0.66	0.57	0.56	0.55	0.56
CC-4 x S1	0.60	0.58	0.59	0.59	0.50	0.49	0.49	0.49
CC-4 x S2	0.74	0.72	0.73	0.73	0.64	0.66	0.66	0.66
Pepper Hot x S1	0.68	0.66	0.66	0.67	0.58	0.58	0.57	0.57
Pepper Hot x S2	0.70	0.68	0.68	0.68	0.62	0.60	0.61	0.61
KDC 1 x S2	0.44	0.42	0.46	0.44	0.39	0.38	0.40	0.39
S1	0.66	0.62	0.62	0.63	0.59	0.54	0.55	0.56
S2	0.61	0.61	0.62	0.61	0.54	0.52	0.52	0.52
CC-4	0.65	0.65	0.65	0.65	0.56	0.57	0.57	0.57
Ujwala	0.67	0.66	0.68	0.67	0.59	0.58	0.59	0.59
Pepper Hot	0.58	0.55	0.53	0.55	0.49	0.48	0.49	0.49
Arka Lohit	0.70	0.68	0.67	0.68	0.59	0.58	0.58	0.59
KDC 1	0.54	0.52	0.53	0.53	0.47	0.46	0.47	0.47
CHD8	0.56	0.52	0.52	0.53	0.41	0.41	0.40	0.41
Mean	0.65	0.63	0.64	0.64	0.56	0.55	0.56	0.56
SEd	0.02	0.04	0.03	0.02	0.02	0.04	0.04	0.03
CD(p=0.05)	0.03	0.08	0.07	0.05	0.05	0.07	0.09	0.06
CD(p=0.01)	0.04	0.11	0.09	0.06	0.0	0.10	0.12	0.08

Among the parent varieties, Arka Lohit exhibited the highest capsaicin content, with percentages of 0.70 and 0.68 in the first and second seasons, respectively, while KDC1 consistently displayed the lowest capsaicin content across all three seasons. Among the hybrids, S1 x Ujwala showcased the highest capsaicin content in healthy ripe fruits, with percentages of 0.78, 0.75, and 0.76 in the first, second, and third seasons, respectively. Pooling the data revealed that Arka Lohit had the highest capsaicin content among the parent varieties, with a percentage of 0.68, while among the hybrids, S1 x Ujwala exhibited the highest value of 0.77 percent, followed by CC-4 x S2 with 0.73 percent.

Capsaicin content in infected fruits (Table 2)

Among the parent varieties, Ujwala and Arka Lohit exhibited the highest capsaicin content in infected fruits during the first and second seasons, with percentages of 0.59 and 0.58, respectively. In contrast, KDC1 consistently displayed the lowest capsaicin content in infected fruits across all seasons, with a percentage of 0.47. Among the hybrids, S1 x Ujwala showcased the highest capsaicin content, with percentages of 0.70, 0.68, and 0.67 in the first, second, and third seasons, respectively. Following this, S1 x CC-4 and CC-4 x S2 recorded capsaicin contents of 0.66 percent each. Pooling the data revealed that Ujwala and Arka Lohit were the parent varieties with the highest capsaicin content in infected fruits, both at 0.59 percent, while S1 x Ujwala was the hybrid with the highest capsaicin content at 0.68 percent, followed by S1 x CC-4 and CC-4 x S2 at 0.66 percent.

In Guwahati (Azad, 1991), the resistant variety of chili peppers exhibited the highest percentage of capsaicin at 1.60 percent, while the susceptible variety had the lowest at 1.20 percent. Additionally, it was observed that the capsaicin content of the fruits had a negative correlation with anthracnose infection on chili fruits. A study on breeding for anthracnose resistance at AVRDC, Taiwan, found that among 56 genotypes, all small-fruited varieties with high capsaicin content, such as Cili Padi, demonstrated resistance to the disease. Moreover, with the exception of the Tampar Skincau variety, which was small and dry, all the resistant cultivars had fleshy fruits of substantial size. Further research (Jeyalakshmi *et al.*, 1999) indicated that diseased chili fruits contained depleted quantities of capsaicin, with a reduction of 50 percent (67.40 mg per 100g). This reduction impacted the pungency principle for which the spice is highly valued.

Pungency stands out as a hallmark characteristic of chili peppers, primarily attributed to a mixture of vanillyl amides including capsaicin, dihydrocapsaicin, nordihydrocapsaicin, homocapsaicin, and homodihydrocapsaicin. Hybrids such as S1 x Ujwala, CC-4 x S2, and S1 x CC-4 exhibited the highest capsaicin levels per se. Notably, hybrids resulting from crosses with low per se values of parents demonstrated high per se values, potentially due to non-additive gene contributions from their respective parentage. Comparisons between the capsaicin content of healthy and infected fruits across various genotypes revealed consistently lower levels in infected fruits across all seasons and in pooled analysis, consistent with findings by Jeyalakshmi *et al.*, (1999). These hybrids hold promise for generating desirable transgressive segregants in subsequent generations, highlighting the potential of harnessing non-additive gene action in breeding programs. Positive heterosis for capsaicin has been noted by Anandanayaki (1997), Ruth Beulah Rani (2002), and Malathi (2004). Comparison with the susceptible check CHD8 indicated higher capsaicin content in all other genotypes, consistent with findings by Azad (1991), who reported higher capsaicin levels in resistant varieties compared to susceptible ones. This positive correlation suggests a potential role of capsaicin in conferring resistance to anthracnose disease, as noted by Agrios (2005) and Tenaya *et al.*, (2001), who found a higher capsaicin level associated with greater anthracnose resistance in red pepper (*C. annuum*). The level of capsaicin content in chili peppers may serve as an indicator of susceptibility to anthracnose disease, providing insight not only into molecular resistance mechanisms but also chemical content. This notion is supported by findings from Raihana Ridzuan *et al.*, (2018) in chili peppers.

Table 3. Oleoresin content of hybrids and parents of chilli in healthy and infected fruits

Hybrids / Parents	Capsaicin content in healthy fruits (%)				Capsaicin content in infected fruits (%)			
	I Season	II Season	III Season	Average	I Season	II Season	III Season	Average
S1 x Ujwala	14.1	14.1	14.3	14.2	12.1	11.6	11.6	11.7
S1 x CC-4	13.9	13.4	13.4	13.6	12.5	11.1	11.1	11.5
S2 x CC-4	13.0	13.1	13.1	13.1	11.4	10.8	10.6	10.9
S2 x Arka Lohit	13.4	13.2	13.3	13.3	11.8	10.8	10.8	11.1
S2 x Pepper Hot	14.6	14.0	14.0	14.2	12.4	12.2	12.4	12.3
Ujwala x S1	14.6	14.6	14.7	14.6	13.3	12.8	12.9	13.0
Ujwala x S2	14.0	14.0	14.3	14.1	11.4	10.9	10.8	11.0
CC-4 x S1	14.0	13.7	13.8	13.8	11.5	10.2	10.9	10.9
CC-4 x S2	14.4	14.9	14.9	14.7	12.2	11.2	11.7	11.7
Pepper Hot x S1	14.7	14.0	14.0	14.2	12.8	10.9	11.0	11.6
Pepper Hot x S2	13.8	13.8	13.7	13.8	10.8	10.5	10.4	10.6
KDC 1 x S2	12.9	13.1	13.3	13.1	10.2	9.8	9.9	9.9
S1	14.2	13.9	13.8	14.0	12.2	11.9	11.8	12.0
S2	13.7	13.7	13.9	13.8	12.1	11.6	12.0	11.9
CC-4	14.6	14.9	14.8	14.8	12.5	12.5	12.6	12.5
Ujwala	14.3	14.5	14.8	14.5	11.6	12.2	12.3	12.0
Pepper Hot	14.0	13.6	13.8	13.8	11.0	10.6	10.7	10.7
Arka Lohit	13.9	14.3	14.4	14.2	11.5	12.1	12.3	12.0
KDC 1	13.6	13.3	13.4	13.4	11.1	10.1	10.4	10.5
CHD8	14.9	15.4	15.3	15.2	9.0	8.8	8.6	8.8
Mean	14.0	14.0	14.1	14.0	11.7	11.1	11.2	11.3
SEd	0.31	0.35	0.35	0.26	0.33	0.46	0.58	0.35
CD(p=0.05)	0.63	0.70	0.70	0.53	0.66	0.94	1.17	0.70
CD(p=0.01)	0.84	0.94	0.94	0.72	0.88	1.26	1.57	0.94

Among the parental genotypes, CC-4 exhibited the highest oleoresin content, measuring 14.0 and 14.9 percent in healthy fruits during the first and second seasons, respectively. In the third season, both CC-4 and Ujwala displayed an oleoresin content of 14.8 percent. Conversely, KDC1 recorded the lowest oleoresin content at 13.4 percent. Among the hybrids, Pepper Hot x S1 showcased the highest oleoresin content in the first season at 14.7 percent, while CC-4 x S2 displayed the highest oleoresin content in the second and third seasons, measuring 14.9 percent. Pooling the data revealed that CC-4 and KDC1 had the highest and lowest oleoresin content among the parental genotypes, respectively, at 14.8 and 13.4 percent. Among the hybrids, CC-4 x S2 exhibited the highest oleoresin content at 14.7 percent, followed by Ujwala x S1 at 14.6 percent.

Oleoresin content in infected fruits (Table 3)

The genotype CC-4 exhibited the highest oleoresin content in infected fruits, with values of 12.5, 12.5, and 12.6 percent in the first, second, and third seasons, respectively, among the parental genotypes. Among the hybrids, Ujwala x S1 recorded the highest oleoresin content, measuring 13.3, 12.8, and 12.9 percent in the first, second, and third seasons, respectively. Pooled data analysis revealed that CC-4 had the highest oleoresin content among the parental genotypes in infected fruits, while Ujwala x S1 showed the highest content among the hybrids at 13.0 percent, followed by S2 x Pepper Hot at 12.3 percent.

Oleoresin is another crucial quality trait contributing to the value addition in chili peppers. The susceptible check CHD8 exhibited the highest oleoresin content in healthy fruits compared to all other genotypes. However, in infected fruits, CHD8 displayed the lowest levels among all genotypes across all three seasons and in pooled analysis. This depletion of oleoresin could be attributed to the infection. It is plausible that upon infection, the oleoresin synthesis continued uninterrupted, potentially suppressing the growth of the organism or preventing further spread of the disease. This finding aligns with the report by Jeyalakshmi *et al.*, (1999), which also noted a 50 percent reduction in oleoresin quantity in diseased fruits.

CONCLUSION

In resistant hybrids, the levels of both capsaicin and oleoresin were notably higher in healthy fruits when contrasted with those affected by anthracnose disease. This suggests that the presence of anthracnose negatively influences the production of these crucial compounds. Moreover, it's noteworthy that hybrids displayed higher capsaicin content in comparison to their parent varieties, indicating a potential enhancement in pungency in the hybrid offspring. Given these findings, it is prudent to prioritize the selection of healthy fruits devoid of anthracnose disease for maximizing the levels of capsaicin and oleoresin in chili peppers. By opting for disease-free fruits, growers can optimize the yield of these valuable compounds, thereby enhancing the overall quality and market value of the chili crop. This emphasizes the importance of disease management strategies and the selection of resistant varieties in chili pepper cultivation to ensure optimal spice and flavor characteristics.

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