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Research Article

Selection of Dried Red Fruits in Hot Pepper Cultivars for Environment-Friendly Cultivation

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Abstract

This study was conducted to select cultivar for dried red fruits in hot pepper suitable for environment-friendly cultivation. For the selection of empirical experimental fields, cultivars were publicly announced targeting 5 places that considered regional characteristics. The number of total fruits in 10 plants has found that #114, #103, and #118 showed the high quantity as 99.5, 87.5, and 85 fruits. For the fresh weight of the total fruits harvested from10 plants, the result has found that #114, #118, and #115 were high as 2491.6g, 2,184.5g, and 1,733.0g. The fruit length has found that #115, #117, and #116 were 175.5mm, 162.5mm, and 160.4mm. The fruit width has found that #120, #123, and #117 were 28.3mm, 25.8mm, and 25.5mm. The fresh weight per fruit has found that #116, #115, and #117 were 33.3g, 32.7g, and 30.3g. The dry weight of the total fruits from 10 plants has found that #114, #118, and #122 were 379.3g, 354g, and 322.8g. The Hunter's color values on fresh fruits have found that L values of #105, #104, and #106 were 33.4, 32.7, and 30.7, #110, #5, and a values of #106 were 17.9, 17.3, and 16.0, and b values of #103, #120, and #119 were 21.5, 19.5, and 19.2. The Hunter's color values on dried fruits have found that L values of #110, #108, and #123 were 33.6, 32.5, and 31.7, a values of #110, #103, and #106 were 19.0, 18.6, and 17.4, and b values of #106, #103, and #108 were 7.8, 7.0, and 6.8. The total capsaicin content has found that #101, #102, and #104 were 81.3mg/100g, 76.2 mg/100g, and 70.1 mg/100g. The total free sugar content has found that #116, #101, and #113 were 17.39g·100g^{-1}, 17.32g·100g^{-1}, and 16.93g·100g^{-1}. The total organic acid content has found that #102, #111, and #114 were 1272.1mg·100g^{-1}, 1266.0mg·100g^{-1}, and 1253.1mg·100g^{-1}. The soluble solid-acid ratio has found that #120, #119, and #118 were 5.1, 7.3, and 8.5. The preference for dried red fruits in hot pepper powder has found that #106, #107, #115, #116, and #120 were high. The disease survey of CMV and TSWV, anthracnose showed #106, #115, #116, #120 were the best. In the results of the study, #106, #115, #116, and #120 were selected as the cultivars suitable for environment-friendly cultivation by comparing cultivars on red fruits in hot pepper with check varieties and ones before and after drying.

Introduction

Chili pepper is a perennial herb which belongs to Solanaceae and the country of origin is South Africa [1]. And it is known that it was introduced into Korea before and after Japanese invasions of Korea about 400 years ago [2]. Chili pepper is one of spices, which are consumed very much in the world because of the various colors and the unique spicy taste. And especially, it is an integral part in Korean food culture as the core seasoning ingredient and food ingredient of main foods of Kimchi, Red Chili Paste (Gochujang), etc. [3]. Chili pepper is mostly stored being dried and processed in the form of powder [4].

Korean chili pepper acres have declined every year as 74,471ha in 2000, 44,584ha in 2010, and 31,146ha in 2020 [5], acres for outdoor culture of dried chili pepper have done to reduce diseases and insect pests, increase the yield, and harvest it early, and acres for greenhouse cultivation have expanded [6-8]. Because greenhouse cultivation of dried chili pepper is usually done in the form of rain proof cultivation, successive application and overuse of fertilizers, continuous cropping of one kind of crop, and salinization in soil are repeated [9] and they have an adverse effect on fragmentation, physicochemistry and biology of soil structure [11]. Because outdoor culture of dried chili pepper is defenselessly exposed to viruses, aphids, mulberry thrips, and anthracnose, chemical pesticides are successively applied to it more than 10 time [12]. Therefore, farmers have a difficulty in creating a Positive List System (PLS) and eco-friendly agricultural products. In this way, there has been an increasing demand for safe agricultural products, however there are lesser studies on varieties of chili pepper suitable for eco-friendly production. Therefore, this study tried to select varieties of chili pepper suitable for eco-friendly cultivation through growing and physicochemical analyses of chili pepper as an empirical study on the production scale of farms.

Materials and Methods

In order to select chili pepper suitable for eco-friendly production, total each 5 experimental fields of 1,000m^2 were created in Sunchang-gun, Jeollabuk-do by considering their semi-mountainous areas and plain areas.

For varieties for the test, total 23 varieties were tested as the numbers 101 to 118 are a cross combination for testing regional adaptability, the number 119 is Sakata Korea's 'Geochanghan (Control)', the numbers 120 to 121 are a cross combination of multiple disease resistance series, the number 122 is Nongwoo's 'Color Jjang', the number 123 is Dongbu's 'Bulpokpo (Fire Waterfall)', and the number 124 is Korea Standard Seed's 'Neostar.' Seeding of chili pepper was done on February 25, 2019 and it was planted in the fields on May 8, 2019. For a survey on the characteristics of chili pepper, each 10 tree by variety were collected and used as specimens for the analyses on August 8, 2019. The preparations for eco-friendly packaging of chili pepper were done by utilizing dried fowl droppings (N : P : K = 2.6 : 3.4 : 1.2%) on the basis of 12.2 kg·10a^{-1} of nitrogen, 6.4 kg·10a^{-1} of phosphoric acid, 6.1 kg·10a^{-1}, of potassium, 2,000 kg·10a^{-1} of compost and barnyard manure, 200 kg·10a^{-1}, of lime, 10~15 cmol$^+$·kg^{-1}, of CEC,

and 2.0dS·m^{-1} of EC in accordance with the standard fertilization prescription criteria by the Rural Development Administration. The number of fruits, fresh weight, fruit length, fruit diameter, weight of one fruit, and chromaticity of harvested chili pepper specimens were investigated. After that, harvested red chili pepper was dried at 65°C for one day and 62°C for two days in a hot air blower and was grounded. Chili pepper powder passed through a 40 mesh, was stored at -40°C in a low-temperature freezer. And it was used as specimens for analyzing contents of Capsaicinoids, free sugar, and organic acid and the solid-acid ratio. For the fresh weight, the weight of whole red chili pepper harvested from ten trees was measured. And for the fruit length, fruit diameter, and weight of one fruit, the 5 fruits which showed the average size of whole red chili pepper harvested by selecting ten trees by variety were selected and the average value was measured. For the dry weight, whole red chili pepper harvested from ten trees by variety was dried and the weight was measured.

The Capsaicinoids analysis was carried out by changing Hoffman's method (Hoffman et al., 1983). 10g of chili pepper powder was put in 200mL of 95% ethanol and was stabilized by heating and cooling it at 60°C for 5 hours. And then, the supernatant was filtered into a 0.45μm membrane filter and 5μL was injected into HPLC (Waters M510 pump, U6K injector, M490 multiwave length UV detector, M740 data). The conditions for analyzing HPLC, Bondapak C18 column (Waters, USA) was used and measured in UV detector 280nm. The compositions of mobile phase are acetonitrile: deionized water (1% acetic acid) = 40:60 and the flow speed was 1.5mL min^{-1}.

For the free sugar analysis, pretreatment was done according to the AOAC method [13] and it was analyzed by changing Lee (1979)'s method. 1g of chili pepper powder was put in 100mL of 80% ethanol, shaking was done at 150rpm for one hour, and centrifugation was done to obtain the supernatant. The supernatant was bleached with activated carbon. In order to remove ethanol, 50mL of distilled water was filled, it was filtered through a 0.2μm membrane filter, and 20μL was injected into HPLC. The column used in the analysis was Sep-pak plus C18 cartridge (Waters, USA), the compositions of mobile phase was acetonitrile: deionized water=80:20, the flow speed was 1.8 mL min^{-1} and the peak was detected from a RI detector (Waters, USA).

For the organic acid analysis, pretreatment was done by changing Coppola's methods (Coppola, 1984) and it was analyzed with HPLC in a UV detector 220nm by using a Sep-pak plus C18 cartridge. HPLC was analyzed by connecting it to μBondapak C18 (10μm, 300 x 7.8mm, Waters, USA) and ODS Hypersil (5μm, 250x4mm, HP, USA) by changing Shaw's method (Shaw & Wilson, 1981) and was detected from a UV detector 220nm. For standard organic acid, 10 of acetic acid, fumaric acid, lactic acid, malic acid, oxalic acid, succinic acid, tartaric acid, cinnamic acid, citric acid, and malonic acid (Sigma Co., USA) were each melt in distilled water, a 1% solution was made and stored in a refrigerator and was used by diluting it to be 0.1%.

The sensory evaluation of overall preference for chili pepper powder was carried out by applying the Gillette Test [14]. For the specimens for the sensory evaluation, chili pepper powder was made three times with 3 fruits by variety and was put in distilled water (Red chili pepper powder:Distilled water=1:1) and was dissolved at 35°C for 30 minutes stirring it. It was filtered through No.4 filter paper (Whatman, UK) and the filtrate which was 10 times diluted was used in the experiment. For the evaluation panel, 60 farmers with chili pepper farming of more than 20 years were selected and divided into two groups. And they participated in the sensory evaluation of growth condition of chili pepper tasting diluted solutions of filtered chili pepper powder in the experimental field of the study. Preference was investigated in order of 1=Dislike it very much and 5=Like it very much with the 5-point scoring system.

The number of infected trees of cucumber mosaic virus (CMV), tomato spotted wilt virus(TSWV), and anthracnose was each investigated as the important diseases of chili pepper and morbidity was calculated. All the analytical data were analyzed in Duncan's multiple range test by using a SAS statistical analysis program (SAS 9.2, SAS Institute., USA).

Results

The survey on growth characteristics

The results of the survey on growth by variety of chili pepper are shown in Table 1. The number of harvested fruits of ten trees by variety has found to show high quantities as the number 114 is 99.5 fruits, the number 103 is 87.5 fruits, and the number 118 is 85 fruits. The fresh weight has found to be high as the number 114 is 2491.6g, the number 118 is 2,184.5g, and the number 115 is 1,733.0g. The fruit length has found to be long in order of the number 115 which is 175.5mm, the number 117 which is 162.5mm, and the number 116 which is 160.4mm. The fruit diameter has found to be long in order of the number 120 which is 28.3mm, the number 123 which is 25.8mm, and the number 117 which is 25.5mm. The weight of one fruit showed 33.3g in the number 116, 32.7g in the number 115, and 30.3g in the number 117. The dry weight is in order of the number 114 which is 379.3g, the number 118 which is 354g, and the number 122 which is 322.8g.

Table 1: Comparison of growth characteristics on each 23 kinds of red fruits in hot pepper fruits.

Cultivar No.	No. of fruits (10 plants)	Fresh weight (g/10 plants)	Fruit length (mm)	Fruit width (mm)	Fresh fruit weight (g/ fruit)	Dried weight (g/10 plants)
101	45.0d	872.5d	112.3e	19.5e	19.2e	150.0d
102	52.0c	1,018.3d	138.4c	22.4d	22.8c	171.3d
103	87.5b	1,154.0c	121.5e	17.6e	14.7e	215.3c
104	59.0c	814.7e	127.9e	17.1e	13.2e	145.5d
105	83.0b	1,049.7c	122.3e	17.4e	13.2e	188.8c
106	50.0c	1,124.5c	129.9d	21.0e	19.8d	178.8c
107	30.0e	819.5e	132.3d	23.7b	26.5b	140.0d
108	35.0d	786.0e	127.6e	21.9d	22.0c	139.3d
110	68.0c	1,276.6c	121.1e	23.2c	18.9e	233.0b
111	35.5d	830.2d	143.0c	23.0c	20.1d	133.8e
112	31.0e	773.9e	137.5c	22.2d	21.3d	116.3e
113	25.0e	853.7d	148.7b	22.5c	24.6c	125.3e
114	99.5a	2,491.6a	152.1b	23.5c	28.9b	379.3a
115	46.5c	1,733.0b	175.5a	24.1b	32.7b	267.8b
116	20.0e	815.0e	160.4b	25.5b	33.3a	120.0e
117	37.0d	1,295.8b	162.5b	25.5b	30.3b	190.0c
118	85.0b	2,184.5b	136.6c	23.2c	24.8c	354.0b
119 Geochanghan	58.5c	1,220.3c	132.0d	22.2d	20.1d	191.5c
120	38.0d	1,133.3c	143.2b	28.3a	27.8b	195.3c
121	31.5e	823.5e	130.9d	23.7b	22.8c	137.3e
122 Kallajjang	84.0b	1,674.0b	137.3c	21.9d	19.7d	322.8b
123 Bulpokpo	26.0e	889.5d	129.4d	25.8b	23.2c	130.0e
124 Neostar	73.5b	1,678.8b	133.8c	22.2d	19.6e	312.5b

[z]Mean separation within columns by Duncan's multiple range test, P=0.05.
[y]101-118: Regional adaptation test lines, 120-121: Multiple disease resistant cross.

Chromaticity

Chromaticity of red chili pepper before and after being dried is shown in Table 2. Chromaticity before being dried has found as follows: The L value which represents the brightness of the chili pepper color has found that the number 105 is 33.4, the number 104 is 32.7, and the number 106 is 30.7. The a value which represents red chromaticity has found that the number 110 is 17.9, the number 105 is 17.3, and the number 106 is 16. The b value which represents yellow chromaticity has found that the number 103 is 21.5, the number 120 is 19.5, and the number 119 is 19.2. The a value which is judged to be most important in chromaticity of chili pepper is the main factor which represents red. The a value of the number 110 which is highest in the study has found to be 19.0. As Lee et al. (2002) reported that the a value of Geumtap (Gold Tower) which was preferred as the reddish variety in the Korean varieties of dried chili pepper in the past was 32.3, it has found to be lower than this. It is thought to be caused by a combination of production environment due to eco-friendly cultivation and genetic differences due to differences of varieties.

Table 2: Comparison of Hunter's color values between fresh fruit and dried one on each 23 kinds of red fruits in hot pepper fruits.

Cultivar No.	Hunter's color value of fresh fruit			Hunter's color value of dried fruit		
	L	a	b	L	a	b
101	29.4b	14.6b	15.0d	31.6b	16.3b	5.9b
102	28.4c	13.2c	17.1d	30.6c	13.0d	5.1c
103	30.1b	14.0b	21.5c	31.3c	18.6b	7.0b
104	32.7b	15.8b	14.6d	31.3c	15.3c	5.1c
105	33.4a	17.3b	18.9c	30.9c	15.3c	4.8c
106	30.7b	16.0b	17.9c	31.5b	17.4b	7.8a
107	27.4d	10.8e	14.0d	28.9e	9.2e	3.3e
108	26.1e	12.0d	13.9d	32.5b	16.6b	6.8b
110	28.9b	17.9a	11.7b	33.6a	19.0a	6.3b
111	28.1c	12.8c	13.4e	31.5b	15.7c	5.4c
112	28.2c	13.0c	11.6e	31.2c	13.9c	4.2d
113	28.0c	12.8c	12.5e	30.0d	13.1c	4.7c
114	24.7e	9.8e	19.0a	30.0d	13.0d	4.0d
115	26.0e	11.8d	13.4b	28.9e	11.4d	4.3d
116	26.2d	13.1c	12.0e	30.2c	12.1d	5.1c
117	27.0d	12.5c	19.0c	28.7e	7.7e	1.9e
118	26.0e	11.2d	17.7b	29.8d	10.7e	2.7e
119	27.5c	12.2d	19.2c	29.9d	13.5c	4.7c
120	25.7e	10.9e	19.5c	29.5e	10.5e	3.1e
121	28.1c	12.3d	13.7e	29.8d	10.0e	2.6e
122	24.8e	10.5e	16.1b	29.7e	12.1d	3.9d
123	26.3d	11.0e	13.0e	31.7b	16.4b	5.5b
124	26.9d	11.2d	15.6b	30.2c	10.0e	2.6e

[z]Mean separation within columns by Duncan's multiple range test, P=0.05.

Chromaticity after being dried has found as follows: The L value has found that the number 110 is 33.6, the number 108 is 32.5, and the number 123 is 31.7. The a value has found that the number 110 is 19.0, the number 103 is 18.6, the number 106 is 17.4. The b value has found that the number 106 is 7.8, the number 103 is 7.0, and the number 108 is 6.8. Chromaticity of chili pepper before being dried has found to be redder than other varieties as the a value of the varieties of the numbers 101 to 106 has found to be high. Chromaticity after being dried has found that the L and a values are evenly high in the varieties of the numbers 101 to 110. The chili pepper varieties used in the study has found that the L and a values before and after being dried are not significantly different. However, in case of the b value which represents yellow chromaticity, the average value before being dried is 15.7, the average value after being dried is 4.6. As the average value after being dried is 3 times lower than the average value before being dried, the red color after being dried could be found to be vivider. Sul et al. [15] reported that the comparison of the b values of ground chili pepper and chili pepper powder has found that ground chili pepper with the lower b value represents the vivid red color.

Contents of Capsaicinoids, free sugar, and organic acid

Chili pepper's contents of capsaicinoids were presented as the total content of the values which measured capsaicin and dihydrocapsaicin which represent its spicy taste and totaled them up (Table 3). The numbers 101 (81.3mg/100g), 102(76.2 mg/100g), and 104(70.1mg/100g) have found to be spicy. On the other hand, the numbers 116 to 119 have found to be unspiciest in the 23 varieties as they are low as the number 116 is 19.2 mg/100g, the number 117 is 11.3 mg/100g, the number 118 is 17.2 mg/100g, and the number 119 is 19.2 mg/100g.

Standard setting of the spicy taste is known as being difficult because of different preference according to differences of the public's eating habit (Huang et al., 2014). The Korean Agency for Technology and Standards divides chili pepper's level of spiciness into 5 of mildly hot (Less than 150mg kg^{-1}), slightly hot (150mg kg^{-1} to 300mg kg^{-1}), medium hot (300mg kg^{-1} to 500mg kg^{-1}), very hot (500mg $kg^{-1}$to 1000mg kg^{-1}), and extremely hot (More than 1000mg kg^{-1}) according to contents of capsaicin and dihydrocapsaicin [16]. For the varieties used in the study in accordance with the above standards, the number 117 was classified into mildly hot, the numbers 113 to 116, 118 to 120, and 122 into slightly hot, the numbers 108 to 112, 121, and 123 into medium hot, and the numbers 101 to 107 into very hot.

The total free sugar content has found that the number 116 is 17.39g $100g^{-1}$, the number 101 is 17.32 g $100g^{-1}$, and the number 113 is 16.93 g $100g^{-1}$ (Table 3). Chili pepper's contents of free sugar are known as the main factor which has an effect on its taste with capsaicin and organic acid. Free sugar's contents were reported to have an effect on the intensity of the spicy taste when capsaicin's contents are low [4,17]. And it was reported that free sugar's contents decrease after being dried due to browning reaction during the drying process [18]. Cho et al. [19], Kim et al. [20] and Hwang et al. [21] has found that chili pepper's contents per reduction is influenced by geographical and environmental factors of the production areas. The chili pepper varieties of the study are judged that differences in free sugar contents came from differences among the varieties because the cultivation areas and drying and storage conditions were identical.

The total organic acid content is shown in Table 3 and showed the high content as the number 102 is 1,272.1mg $100g^{-1}$, the number 111 is 1,266.0 mg $100g^{-1}$, and the number 114 is 1,253.1 mg $100g^{-1}$.

Table 3: Comparison of preference priority on each 23 kinds of dried pepper fruits.

Cultivar No.	Capsaicinoids (mg/100g)	Free sugar (g·100g^{-1})	Organic acid (mg·100g^{-1})	Solid-acid ratio
101	81.3a	17.32a	1132.3d	15.3a
102	76.2b	12.85d	1272.1ab	10.1c
103	69.4b	13.94c	1245.2b	11.19b
104	70.1b	10.89e	1109.32d	9.82c
105	58.9b	15.06bc	1083.8de	13.9a
106	60.1b	16.83a	1354.7a	12.42b
107	50.3c	16.07ab	1108.4d	14.5a
108	40.4c	10.55e	1098.5de	9.6d
110	32.8c	18.8a	1051.9e	17.87a
111	33.5c	13.38c	1266.0b	10.57c
112	36.2c	15.95ab	1198.5c	13.31b
113	29.0d	16.93a	1204.5bc	14.06a
114	25.1d	12.32d	1253.1b	9.83c
115	20.3e	13.85c	1309.2a	10.58b
116	19.2e	17.39a	1207.4bc	14.4a
117	11.3e	10.83e	1108.4d	9.77c
118	17.2e	9.74ef	1148.6d	8.48d
119	19.2e	8.85f	1206.4bc	7.34d
120	29.7d	6.04g	1175.2cd	5.14d
121	35.8c	10.93e	1130.5d	9.67d
122	29.0d	14.32c	1206.1bc	11.87b
123	31.5d	15.96b	1190.2c	13.41b
124	21.8e	12.09d	1185.4c	10.2c

[z]Mean separation within columns by Duncan's multiple range test, P=0.05.

The solid-acid ratio is free sugar/organic acid and has found to be high in the numbers 110 (17.9), 101 (15.3), 107 (14.5), 116 (14.4), and 113 (14.1) and low in the numbers 120 (5.1), 119 (7.3), 118 (8.5), and 108 (9.6) (Table 3). Chili pepper's taste is determined by capsaicinoids' content and the solid-acid ratio. Capsicinoids's content determines strong pungency, however preference for each individual taste of chili pepper is influenced by

the solid-acid ratio. Especially for the solid-acid ratio, the content ratios of total free sugar and total organic acid are significantly different according to the varieties. It is reported that the higher values are, the more linearity with higher preference for the chili pepper taste accords with the solid-acid ratio [22].

Preference survey

A preference survey on dried chili pepper powder has found that preference for the numbers 106, 107, 115, 116, and 120 is high (Table 4). Soh et al. [22] reported that chili pepper's taste is caused by multiple factors because it shows a very correlationship in a single factor as the spicy taste is R=0.149, free sugar is R=0.473, and organic acid is R=0.382. The study has found that preference for the numbers 101 and 102 with the high total capsaicin content is low. It is interpreted as the similar result with the report that preference of sensory evaluation is low because it is difficult to sense other tastes which determine preference because of the strong spicy taste when reaching the critical point to sense the spicy taste [22]. In addition, the result which conducted a regression analysis on the priority of preference for dried chili pepper and the characteristics of preference, capsaicin, the solid-acid ratio, and productivity showed the high correlationship as the R2 value is 0.95 (Figure 1). As a result, the numbers 115, 106, 116, and 120 with the high priority became Group which is highest in 5 groups.

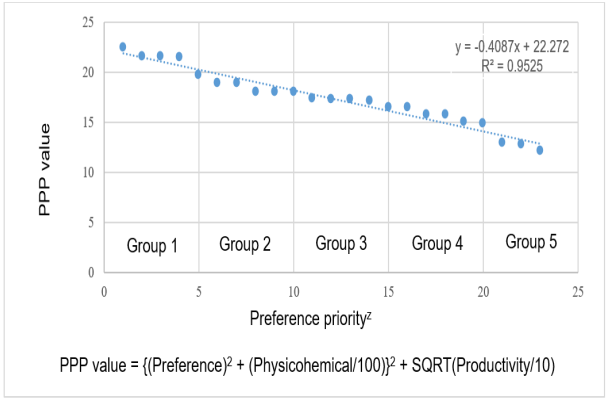

Figure 1: Regression analysis between preference priority and characterization on each 23 kinds of dried red fruits in hot pepper powder

[z]Preference priority: 115, 106, 116, 120, 107, 105, 101, 103, 121, 108, 114, 119, 102, 104, 117, 113, 118, 110, 124, 111, 122, 112, 123

Survey on chili pepper's blight

Infected plants of CMV, TSWV, and anthracnose known as the important diseases which occur in experimental fields of chili pepper were investigated (Table 4). Anthracnose has found that the disease incidence increases due to chili pepper's major disease, especially, an increase in precipitation and the average temperature [23]. CMV. Lee et al. [24] investigated that CMV is a virus with the highest dominance ratio in the viral diseases which occur in chili pepper. TSWV is a virus which is very pathogenic with the wide host range and was reported to continue to cause a viral disease in chili pepper since 2006 [25]. CMV's disease incidence was lowest as the number 104 is 5.5%, the number 106 is 0.3%, the number 107 is 6.1%, the number 115 is 2.4%, the number 116 is 3.4%, the number 120 is 3.6%, the number 121 is 4.3%, and the number 122 is 5.9%. The above variety is thought that initial CMV incidence is low because it was derived from the chili pepper series with high resistance to CMV-fny. TSWV disease incidence which causes TSWV has found to be low as the number 101 is 1.2%, the number 102 is 0.2%, the number 103 is 0.1%, the number 104 is 0%, the number 106 is 1.9%, the number 115 is 0%, the number 116 is 0.5%, the number 120 is 1.7%, and the 121 is 0%. Anthracnose disease incidence was lowest as the number 106 is 17.9%, the number 115 is 15.3%, the number 116 is 14.1%, and the number 120 is 18.1%. The numbers 106, 115, 116, and 120 which showed the lowest disease incidence of CMV, TSWV, and anthracnose that is most important in current cultivation of chili pepper have found to be most favorable for eco-friendly cultivation as the multiple disease resistance variety (Table 5).

Table 4: Sensory evaluation on each 23 kinds of dried red fruits in hot pepper powder.

Cultivar No.	Preference
101	4.3c
102	4.1e
103	4.2d
104	4.1e
105	4.3c
106	4.6b
107	4.4c
108	4.2d
110	3.9g
111	3.8g
112	3.5h
113	4.0e
114	4.1e
115	4.7a
116	4.6b
117	4.0f
118	3.9g
119	4.1e
120	4.6b
121	4.2d
122	3.5h
123	3.4i
124	3.8g

Table 5: Ratio of CMV, TSWV, anthracnose on each 23 kinds of dried red fruits in hot pepper.

	Ratio of Disease (%)		
	CMV	TSWV	Anthracnose
101	24.3cz	1.2b	48.7d
102	31.9d	0.2b	41.3d
103	28.4c	0.1b	39.8d
104	5.5a	0.0a	21.6b
105	4.3a	5.4c	24.5b
106	0.3a	1.9b	17.9a
107	6.1a	8.4c	23.9b
108	11.8b	10.1c	27.2c
110	12.7b	0.4b	23.5b
111	11.6b	2.3c	26.1c
112	11.1b	3.7c	24.6b

113	9.8b	4.5c	36.8c
114	10.7b	6.6c	54.5e
115	2.4a	0.0a	15.3a
116	3.4a	0.5b	14.1a
117	8.7b	11.4d	66.3e
118	18.6c	11.8d	56.1e
119	19.2c	12.4d	50.2e
120	3.6a	1.7b	18.1a
121	4.3a	0.0a	49.6d
122	5.9a	4.4c	42.1d
123	26.5c	3.9c	38.6c
124	22.6c	10.2d	25.3c

[z]Mean separation within columns by Duncan's multiple range test, P=0.05.

In the results of the study, 22 varieties of chili pepper before and after being dried were compared with control varieties and 4 varieties of the numbers 106, 115, 116, and 120 with high preference and less blight damage were selected as the varieties suitable for eco-friendly cultivation. This does not accord with the physicochemical analytical result. It is thought that elements of the number of fruit set and the quantity are multiply reflected in terms of improving incomes of farmers [26-30].

Summary

a) The study was conducted to select chili pepper varieties suitable for eco-friendly cultivation.

b) The number of fruits showed the higher quantity in order of the numbers 114 (99.5), 103(87.5), 118(85).

c) The fresh weight was higher in order of the numbers 114(2,491.6g), 118(2,184.5g), and 115(1,733.0g).

d) The fruit length was heavier in order of the numbers 115(175.5mm), 117(162.5mm), and 116(160.4mm).

e) The fruit diameter was larger in order of the numbers 120(28.3mm), 123(25.8mm), and 117(25.5mm).

f) The weight of one fruit showed the higher fresh weight in order of the numbers 116 (33.3g), 115(32.7g), and 117(30.3g).

g) The quantity of dried fruits of ten trees has found to be higher in order of the number 114(379.3g), 118(354g), and 122(322.8g).

h) Chromaticity before being dried was higher as the L values are 33.4 in the number 105, 32.7 in the number 104, and 30.7 in the number 106, the a values are 17.9 in the number 110, 17.3 in the number 105, and 16.0 in the number 106, and the b values are 21.5 in the number 103, 19.5 in the number 120, and 19.2 in the number 119. Chromaticity after being dried was higher as the L values are 33.6 in the number 110, 32.5 in the number 108, and 31.7 in the number 123, the a values are 19.0 in the number 110, 19.0 in the number 103, 18.6 in the number 103, and 17.4 in the number 106, and the b values are 7.8 in the number 106, 7.0 in the number 103, and 6.8 in the number 108.

i) The total capsaicin content has found to be very spicy in order of the numbers 101 (81.3mg/100g), 102 (76.2mg/100g), and 104 (70.1mg/100g. The free sugar content was higher in order of the numbers 116 (17.39g $100g^{-1}$), 101 (17.32g 100g-1), and 113 (16.93g $100g^{-1}$). The organic acid content has found to be in order of the numbers 102 (1272.1mg $100g^{-1}$), 111 (1266.0mg $100g^{-1}$), and 114 (1253.1mgž$100g^{-1}$). And the solid-acid ratio has found to be in order of the numbers 120 (5.1), 119 (7.3), and 118(8.5).

j) The preference survey on dried chili pepper powder has found that preference for the numbers 106, 107, 115, 116, and 120 is high.

k) In the survey on CMV, TSWV, and anthracnose known as the main diseases of chili pepper, 4 varieties of the numbers 106, 115, 116, and 120 were selected as the multiple disease resistance varieties suitable for eco-friendly cultivation as their disease incidence has found to be lowest.

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