

Analysis on Antioxidant Activity of the New Developed Waxy Corn Hybrids

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ABSTRACT A total of CNU 28 colored hybrids developed at the Chungnam National University were evaluated to identify new cultivars with functionality. These color waxy corn hybrids appeared to have high antioxidant activity. The SOD activity in the developed color waxy corn was high; CNU13H-3, in white hybrid, and CNU13H-44, in yellow hybrid, was 5% and 27% higher than the Yeonngong and Daehakchal Gold 1 of control hybrids, respectively. The DPPH activity in CNU13H-44, of yellow hybrid, and CNU13H-75 of purple hybrid were high as 32.6 mg/g and 40.1 mg/g, respectively. We have already reported that color hybrids have high antioxidant activity. In this study also was same results. On the basis of our findings, these hybrids will be planted in next time to compare their productivity and area adaptation.

Keywords : antioxidant, activity, superoxide anion radical, hybrid corn

Corn was evaluated aging inhibition and adult diseases protection due to oxidative metabolism by free radicals in the body. Most of colored corns have stronger antioxidant properties than colorless corn and also have superior DPPH radical scavenging ability(Lee *et al.*, 2005). Ismail *et al.*(2010) reported that oxygen free radicals induce cell membrane destruction by acting on proteins, which are also involved with hypertension and aging.

Yu *et al.* (2006) reported that 2,2-diphenyl-1-picrylhydrazyl (DPPH) was a comparatively stable on free radical phenolic compound that inhibited damage caused by free radicals because of its potent ability to reduce free radicals.

Besides, superoxide anion radical (SOD) was well known as a powerful radical that was generated during the cell-oxidation reaction. Although it cannot directly affect lipid oxidation and

is known as a precursor of other oxygen free radicals with strong reactivity, and induces oxidative injury in humans. Li *et al.* (2008) reported that reducing SOD was beneficial to human health.

Based on the above facts, this study was conducted to gain basic informations and to identify possible complex hybrids of corn by evaluating the agronomic characteristics and assessing the functional components in color waxy corn hybrids.

MATERIALS & METHODS

Plant materials

The used materials were CNU hybrids described in Table 1. and cultivation methods were same as contents reported in J. of Crop Sci. 60(2) (Na *et al.*, 2015).

Determination of antioxidant activity

Pre-treatment of samples

The used hybrid corn kernels that were used for physicochemical analysis were immediately frozen after sampling and lyophilized in freeze dryer at 5 μ m Hg pressure and -80°C . Samples were pulverized using a disintegrator and sifted through a 24-mesh sieve. Samples from each corn hybrid were sealed in a plastic bag and kept at -20°C . The supernatant was filtered through Whatman No.1 filter paper and was concentrated using a rotary evaporator. The concentrated solutions were used for assessing antioxidant activities.

Measurement of antioxidant

The free radical scavenging activity of extracted sample in the colored waxy corn hybrids was measured by the DPPH method proposed by Blois (1958).

An SOD assay kit (Dojindo Laboratories) was used to

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Table 1. DPPH radical scavenging activity in CNU waxy corn hybrid

Characteristics Hybrids	Absorbance (450nm)	Index	Kernel color
CNU13H- 3	10.8±10.4 ^b	35	white
CNU13H- 9	19.5±7.6 ^{a-b}	63	white
CNU13H-16	18.6±8.4 ^{a-b}	61	white
CNU13H-23	24.6±4.5 ^{a-b}	80	white
CNU13H-24	21.9±6.9 ^{a-b}	71	white
CNU13H-26	23.4±7.2 ^{a-b}	76	white
CNU13H-27	15.9±14.2 ^{a-b}	52	white
CNU13H-73	33.0±7.2 ^a	107	white
Mibak 2 [†]	19.8±5.4 ^{a-b}	64	white
Yeonmong [†]	30.7±12.8 ^a	100	white
Mean	21.8	71.1	-
C.V(%)	30.2	30.2	-
CNU13H-29	21.2±3.3 ^{a-b}	170	yellow
CNU13H-34	22.0±3.2 ^{a-b}	176	yellow
CNU13H-35	27.1±5.7 ^{a-b}	217	yellow
CNU13H-36	26.9±8.5 ^{a-b}	216	yellow
CNU13H-39	21.3±18.0 ^{a-b}	171	yellow
CNU13H-40	8.7±10.8 ^b	69	yellow
CNU13H-44	32.6±18.0 ^a	261	yellow
CNU13H-69	26.8±10.0 ^{a-b}	215	yellow
CNU13H-70	17.9±7.6 ^{a-b}	143	yellow
CNU13H-71	27.8±5.6 ^{a-b}	223	yellow
CNU13H-96	26.3±1.7 ^{a-b}	211	yellow
CNU13H-97	21.9±2.2 ^{a-b}	175	yellow
CNU13H-98	23.5±4.3 ^{a-b}	189	yellow
Daehackchal Gold1 [†]	12.5±9.6 ^b	100	yellow
Mean	22.6	181.3	-
C.V(%)	28.0	28.0	-
CNU13H-46	33.8±10.7 ^{a-b}	152	purple
CNU13H-55	18.4±11.6 ^b	83	purple
CNU13H-74	13.6±11.7 ^b	61	purple
CNU13H-75	40.1±12.5 ^a	181	purple
CNU13H-77	27.1±10.2 ^{a-b}	122	purple
CNU13H-79	19.6±8.0 ^{a-b}	88	purple
CNU13H-80	21.1±13.0 ^{a-b}	95	purple
Miheuckchal [†]	22.2±6.6 ^{a-b}	100	purple
Mean	24.5	110.4	-
C.V(%)	35.6	35.6	-
Total mean	22	72.6	-
C.V(%)	30	30	-

In a column means followed by a common letter are not significantly different at the 5% level by DMRT

*Means ±Standard Error

[†]Control hybrids

determine the SOD activity. The anthocyanin content was determined according to the method described by Yang (2008) with modifications. The carotenoid content of corn kernel was estimated by the method described by Handelman (1996).

Statistical analysis

Mean difference of functional components on the used hybrids were compared using the SAS program (v. 9.3).

RESULTS & DISCUSSION

DPPH radical scavenging

DPPH radical scavenging activity estimated to determine the antioxidant activity of the waxy corn hybrids (Table 1). The average DPPH radical scavenging activity in colored waxy corn was 22. CNU13H-44 among hybrids showed as a highly 261% than check. In white corn, CNU13H-73 showed a higher activity than the control. Most of the yellow corn hybrids was higher than that of the control hybrid except CNU13H-40. The purple CNU13H-75 hybrid appeared to have a high DPPH radical scavenging activity as a 181%, and was followed by CNU13H-75 and CNU13H-46. Yu *et al.* (2006) reported that phenolic compounds have been reported to inhibit damages in the body caused by free radicals because it has a potent capability of reducing free radicals. Lee *et al.* (2006) and Lee *et al.* (2005) reported that colored waxy corn has been reported to contain more antioxidants than colorless corn and has superior DPPH radical scavenging activity.

SOD anion radical scavenging activity

SOD activity of the colored waxy corn hybrids showed in Table 2. The SOD activity ranged from 15.6 mg/g to 32.7 mg/g. Among the hybrids, CNU13H-44 showed the highest SOD activity (32.7 mg/g) and was followed by CNU13H-29, which showed an SOD activity of 31.8 mg/g. CNU13H-3 with a white colored hybrid and CNU13H-44 and CNU13H-29 with yellow colored hybrids showed high SOD activities, but SOD activity of most purple colored hybrids showed lowly than control hybrids. About these facts, Li *et al.* (2008) reported that reducing superoxide anion radical is significantly useful for human health.

Table 2. Superoxide anion radical scavenging activity in CNU waxy corn hybrids

Characteristics Hybrids	Inhibition (mg/g)	Index	Kernel color
CNU13H- 3	31.3±1.3 ^a	105	white
CNU13H- 9	22.9±1.1 ^{b-c}	77	white
CNU13H-16	25.8±5.8 ^{a-b}	86	white
CNU13H-23	15.6±4.9 ^c	52	white
CNU13H-24	15.7±7.6 ^c	52	white
CNU13H-26	23.4±3.7 ^{b-c}	78	white
CNU13H-27	22.9±2.9 ^{b-c}	77	white
CNU13H-73	22.8±0.9 ^{b-c}	76	white
Mibak 2 [†]	22.6±5.8 ^{b-c}	76	white
Yeonmong [†]	29.8±1.9 ^{a-b}	100	white
Mean	23.3	78	-
C.V(%)	21.8	22	-
CNU13H-29	31.8±1.8 ^{a-b}	123	yellow
CNU13H-34	17.7±1.8 ^{d-e}	68	yellow
CNU13H-35	23.6±0.1 ^{c-d}	91	yellow
CNU13H-36	31.5±1.5 ^{a-b}	122	yellow
CNU13H-39	23.8±8.7 ^{c-d}	92	yellow
CNU13H-40	26.8±4.7 ^{a-c}	104	yellow
CNU13H-44	32.7±1.3 ^a	127	yellow
CNU13H-69	25.8±5.2 ^{b-c}	100	yellow
CNU13H-70	22.8±1.8 ^{c-e}	88	yellow
CNU13H-71	23.0±3.0 ^{c-d}	89	yellow
CNU13H-96	22.8±4.3 ^{c-e}	88	yellow
CNU13H-97	27.0±2.1 ^{a-c}	105	yellow
CNU13H-98	16.5±1.6 ^e	64	yellow
Daehackchal Gold1 [†]	25.8±1.5 ^{b-c}	100	yellow
Mean	25.1	97	-
C.V(%)	19.1	19	-
CNU13H-46	18.5±1.5 ^c	62	purple
CNU13H-55	28.1±5.9 ^a	94	purple
CNU13H-74	25.8±3.8 ^{a-b}	87	purple
CNU13H-75	26.3±2.3 ^{a-b}	89	purple
CNU13H-77	25.4±1.2 ^{a-b}	86	purple
CNU13H-79	18.9±1.1 ^c	64	purple
CNU13H-80	22.0±1.0 ^{b-c}	74	purple
Miheuckchal [†]	29.7±1.7 ^a	100	purple
Mean	24.3	82	-
C.V(%)	16.9	17	-
Total mean	24.2	89.7	-
Total C.V(%)	19.4	19.4	-

In a column, means followed by a common letter are not significantly different at the 5% level by DMRT

*Means± Standard Error

[†]Control hybrids

Table 3. Comparison of anthocyanin contents in CNU waxy corn hybrids

Characteristics Hybrids	Absorbance (530nm)	Anthocyanin content (mg/g)	Index	Kernel color
CNU13H- 3	0.035	0.035±0.03 ^a	128	white
CNU13H- 9	0.039	0.040±0.03 ^a	146	white
CNU13H-16	0.066	0.068±0.10 ^a	246	white
CNU13H-23	0.029	0.030±0.03 ^a	107	white
CNU13H-24	0.038	0.039±0.05 ^a	141	white
CNU13H-26	0.045	0.046±0.05 ^a	167	white
CNU13H-27	0.084	0.086±0.13 ^a	311	white
CNU13H-73	0.054	0.055±0.05 ^a	199	white
Mibak 2 [†]	0.027	0.027±0.02 ^a	100	white
Yeonmong [†]	0.019	0.020±0.01 ^a	72	white
Mean	0.044	0.04	161.7	-
C.V(%)	44.9	44.9	44.9	-
CNU13H-29	0.047	0.048±0.03 ^a	246	yellow
CNU13H-34	0.025	0.026±0.01 ^a	133	yellow
CNU13H-35	0.060	0.061±0.07 ^a	314	yellow
CNU13H-36	0.031	0.032±0.02 ^a	165	yellow
CNU13H-39	0.055	0.056±0.07 ^a	291	yellow
CNU13H-40	0.016	0.017±0.02 ^a	86	yellow
CNU13H-44	0.019	0.019±0.01 ^a	100	yellow
CNU13H-69	0.033	0.033±0.02 ^a	172	yellow
CNU13H-70	0.067	0.068±0.06 ^a	351	yellow
CNU13H-71	0.069	0.070±0.02 ^a	361	yellow
CNU13H-96	0.027	0.027±0.03 ^a	140	yellow
CNU13H-97	0.053	0.054±0.07 ^a	281	yellow
CNU13H-98	0.015	0.015±0.01 ^a	79	yellow
Daehackchal Gold1 [†]	0.019	0.019±0.01 ^a	100	yellow
Mean	0.038	0.04	201.4	-
C.V(%)	50.9	50.9	50.9	-
CNU13H-46	0.153	0.156±0.13 ^{a-b}	489	purple
CNU13H-55	0.042	0.042±0.05 ^b	133	purple
CNU13H-74	0.165	0.168±0.04 ^{a-b}	528	purple
CNU13H-75	0.215	0.219±0.16 ^a	685	purple
CNU13H-77	0.178	0.181±0.04 ^{a-b}	567	purple
CNU13H-79	0.095	0.096±0.03 ^{a-b}	302	purple
CNU13H-80	0.038	0.038±0.05 ^b	120	purple
Miheuckchal [†]	0.031	0.032±0.01 ^b	100	purple
Mean	0.115	0.12	365.5	-
C.V(%)	63.2	63.2	63.2	-
Total mean	0.059	0.06	230.0	-
C.V(%)	85.0	85.0	68.2	-

In a column, means followed by a common letter are not significantly different at the 5% level by DMRT

*Means± Standard Error

[†]Control hybrids

Table 4. Comparison of carotenoid contents in CNU waxy corn hybrids

Characteristics Hybrids	Absorbance (450nm)	Carotenoid content (mg/g)	Index	Kernel color
CNU13H- 3	0.072	1.4±0.2 ^c	60	white
CNU13H- 9	0.072	1.4±0.1 ^c	61	white
CNU13H-16	0.095	1.9±0.4 ^{b-c}	80	white
CNU13H-23	0.135	2.7±0.1 ^{a-b}	113	white
CNU13H-24	0.125	2.5±0.9 ^{a-b}	106	white
CNU13H-26	0.099	2.0±0.1 ^{b-c}	84	white
CNU13H-27	0.133	2.6±0.4 ^{a-b}	111	white
CNU13H-73	0.151	3.0±0.8 ^a	127	white
Mibak 2†	0.105	2.1±0.4 ^{a-c}	88	white
Yeonong†	0.119	2.3±0.6 ^{a-b}	100	white
Mean	0.111	2.2	93.0	-
C.V(%)	24.1	24.0	24.0	-
CNU13H-29	0.199	3.9±0.8 ^{c-c}	83	yellow
CNU13H-34	0.211	4.2±0.1 ^{c-d}	88	yellow
CNU13H-35	0.255	5.0±1.4 ^{b-c}	107	yellow
CNU13H-36	0.134	2.7±0.2 ^{c-g}	56	yellow
CNU13H-39	0.183	3.6±1.7 ^{c-f}	77	yellow
CNU13H-40	0.206	4.1±0.6 ^{c-c}	86	yellow
CNU13H-44	0.323	6.4±1.2 ^b	135	yellow
CNU13H-69	0.119	2.3±0.5 ^{f-g}	49	yellow
CNU13H-70	0.097	1.9±0.2 ^g	40	yellow
CNU13H-71	0.644	12.6±0.1 ^a	268	yellow
CNU13H-96	0.248	4.9±0.9 ^{c-d}	103	yellow
CNU13H-97	0.260	5.1±0.6 ^{b-c}	109	yellow
CNU13H-98	0.183	3.6±0.5 ^{d-f}	75	yellow
Daehackchal Gold1†	0.239	4.7±0.1 ^{c-d}	100	yellow
Mean	0.236	4.6	98.3	-
C.V(%)	56.0	55.9	56	-
CNU13H-46	0.189	3.7±0.9 ^a	159	purple
CNU13H-55	0.146	2.9±0.6 ^a	122	purple
CNU13H-74	0.155	3.0±0.4 ^a	128	purple
CNU13H-75	0.178	3.5±0.6 ^a	149	purple
CNU13H-77	0.199	3.9±1.6 ^a	166	purple
CNU13H-79	0.161	3.2±1.2 ^a	135	purple
CNU13H-80	0.166	3.3±1.0 ^a	139	purple
Miheuckchal†	0.120	2.4±0.4 ^a	100	purple
Mean	0.164	3.2	137.3	-
C.V(%)	15.4	15.4	15.5	-
Total mean	0.177	3.5	106.4	-
Total C.V(%)	59	59	40.5	-

In a column, means followed by a common letter are not significantly different at the 5% level by DMRT

*Means± Standard Error

†Control hybrids

Anthocyanin pigment content

The anthocyanin content of the 28 hybrids was detected at 530 nm (Table 3). Among the hybrids, the purple colored waxy corn hybrids including CNU13H-75, CNU13H-77 and CNU13H-74 had higher than the control hybrid, Miheuckchal. These hybrids had estimated anthocyanin contents of 0.219 mg/g, 0.181 mg/g, and 0.168 mg/g, respectively. Additionally, CNU13H-27 as a white hybrid, and CNU13H-71 as a yellow hybrid, had high anthocyanin contents. These facts were same an other reports (Kim *et al.*, 2005) They reported that five types of pigments were separated in black corn, especially, C3G level was higher than other pigments.

Carotenoid pigment content

The carotenoid pigment content in the CNU 28 waxy corn hybrids was analyzed at 420 nm (Table 4) according to the method described by Handelsman. The carotenoid content of corn kernel varied regardless of color corn. Among the hybrids, the carotenoid content in the yellow colored corn (4.6 mg/g) was higher than that in the purple and white colored corn. Especially, CNU13H-71 of yellow hybrid had the highest carotenoid content of 12.6 mg/g, and CNU13H-73, a white hybrid, had the lowest a carotenoid content of 3.0 mg/g. Lambert *et al.*, (1990) and Mayne (1996) reported that carotenoid is a natural pigment that is typically distributed widely in nature and is mainly included in red and yellow colored vegetable crops.

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