

Research Article



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국내 육성된 향미 품종의이앙시기별 이화학적 특성 및 향기성분 비교 분석

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Physicochemical Characteristics of Cultivated Aromatic Rice Germplasm and Comparative Analysis of Flavor Components During Transplanting Time

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Abstract

BACKGROUND: The Aromatic rice which is characterized by the flavor of Nurungji when cooked rice, and consumption is increasing recently. The purpose of this study was to investigate the physicochemical characteristics and aroma components of five aromatic rice cultivars according to transplanting time.

METHODS AND RESULTS: Quantitative analysis of protein, fat, fatty acid and essential amino acid for five aroma rice cultivars(Hyangmibyeo 2 ho, Aromi, Mihyang, Aranghyangchal, Heughyang)and transplanting time was analyzed by crude protein analyzer, gas chromatography (GC), liquid chromatography (LC) and viscosity analysis was done by using rapid viscosity analyzer (RVA). The content of 2-acetyl-1-pyrroline (2AP) was determined by gas chromatography mass spectrometer. (GC-MS) As a result, the average protein and lipid contents were 6.5% and 2.4%, respectively. The content of essential amino acid showed the highest content at 104.4mg/g. There was no

significant change in normal nutrients during the transplanting time. By RVA, cv.Hyangmibyeo 2 ho showed the highest peak and total setback viscosities and lowest breakdown viscosity in early transplantation. The content of 2AP in flavor varieties and transplanting time was quantitatively analyzed by GC-MS. Among the cultivars, Aromi showed the highest 2AP contents at 66.7 µg/100g in normal transplanting time.

CONCLUSION: cv.Aromi and Hyangmibyeo 2 ho were excellent physicochemical properties and 2AP components contents amongaromatic rice cultivars tested. Their optimal time to transplant was at the beginning of June in the area of Miryang.

Key words: Aroma components, Aromatic rice, GC-MS, LC, Physicochemical properties, RVA, 2-acetyl-1-pyrroline

서론

가

가

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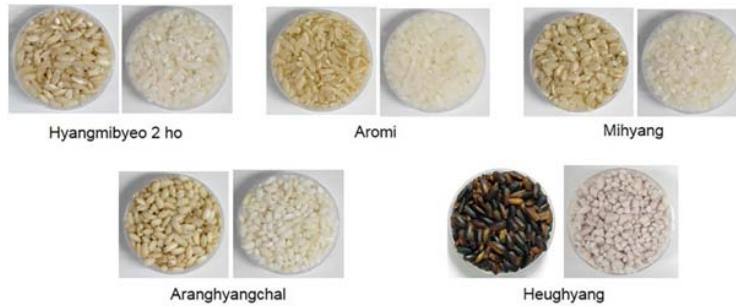


Fig. 1. Whole grain (left) and polished aromatic rice (right) cultivars.

(Oh *et al.*, 2015). , 1 가 가 가 , 가 2AP 가 가 (Son *et al.*, 2002). (Kim and Kim, 1987) (Gomez and Datta, 1975; Juliano, 1985) (Son *et al.*, 2002) 가 가 가 (Choi *et al.*, 2012), (Somponget *et al.*, 2011) (Jang *et al.*, 2015) 가 (Hu *et al.*, 2003) (Shao *et al.*, 2015) 가 가 가 가 (Buttery *et al.*, 1988). 1970 (Lee *et al.*, 1991)가 1993 1 (Choi *et al.*, 1995) (Ha *et al.*, 1996), 2 (Moon *et al.*, 1998) 가 (Gas chromatography, GC) (Gas chromatography Mass, GC-MS) 200 (Bryant and McClung, 2011; Mahmud *et al.*, 2016). 2-acetyl-1-pyrroline (2AP)가 (Lee and Kim, 1999; Kim *et al.*, 2008; Wakteet *et al.*, 2016).

재료 및 방법

시험재료 및 재배방법

Hyangmibyeo 2 ho, Aromi, Mihyang, Aranghyangchal, Heughyang 5 (Fig. 1) 5 2 , 5 15 , 6 1 180 g 20 10a 9 kg, 4.5 kg, 5.7 kg 30×15 cm .

시약

2-Acetyl-1-pyrroline (2AP) Parchem fine & Specialty Chemicals (NY, USA) , Amylose from potatoes fatty acid methyl ester Sigma Chemical Co. (St Louis, MO, USA) . AQC-Derivatized Amino Acid Waters (MA, USA) .

이화학적 특성평가

15%가 4°C (, SYY88-TH) , 1 100 Mesh 가 . 1) , Kjeldahl (Juliano, 1985) (Kjeltec Auto Anlayzer, Foss, USA) . 2 g 200 mL Kjeldahl (H₂SO₄) 10 mL 가 1 g 40 0°C 2 h . 3 150 mL 가 45%가 (NaOH) 5 mL 가 35 mL , 2%

(H₃BO₄) 5mL 0.1 N
 (N) , 5.95(%)
 10 g 90°C
 3 h
 Soxhlet 24 h
 90°C
 Soxhlet
 2)
 (Kim *et al.*, 2014)
 Soxhlet 100 mL
 200 mg 0.5 N
 NaOH/MeOH 10 mL 가 .
 가 가 가 10%
 BF3/MeOH 5 mL 5 min
 . 5 mL n-
 15 mL
 n-
 (Na₂SO₄) (Flame
 Ionization Detector, FID)가 GC (Agilent 7890A
 system, Agilent, CA, USA)
 HP-INNOWax (30 m×0.25 mm×0.25 μm, Agilent),
 260°C . 200°C,
 60°C /5 min 10°C 250°C /5
 min
 3)
 Juliano (1971) 0.1 g
 95% 1 mL 1 N NaOH 9 mL
 15 min 3 100
 mL가 , 10 mL 1 N
 () 2 mL 2% I₂-KI (Iodine) 4 mL
 3 100 mL 30°C 20 min
 UV/Vis (620 nm)
 4)
 (2 g) 80%(v/v) 25 mL 가 30°C
 4 hr , (3,000 rpm,10 min)
 80% 50 mL
 1 mL 5%
 1 mL 가 5 min , (10,000
 rpm, 10 min) . 0.02 N 1
 mL 가 , 0.2 μm
 Waters (MA, USA) AccQ-Tag

amino acid analysis AccQ Tag amino acid
 analysis column (3.9×150 mm, Waters, MA, USA)
 (ACQUITY UPLC system,
 Waters, MA, USA)

아밀로그램 및 호화특성 분석

Rapid Visco Analyzer
 (Newport, RVA-3D, UK) 2 g 2
 mL 50°C 1
 min, 50-90°C 10°C 90°C 3 min
 50°C
 (gelatinization temperature), (hot viscosity),
 (peak viscosity), (cool viscosity)
 , (breakdown)
 (setback)
 (Deffenbaugh and Walker, 1989;
 Kim *et al.*, 2012).

2AP 향기성분정량분석

2AP
 10 g 20 mL Headspace sampler (HSS)
 headspace autosampler (LECO, USA)
 90°C 30 min
 1
 mL 2AP
 GC 2 TOF-MS 가 Pegasus 4D (LECO,
 USA) 1 Rtx-5MS (30 m×
 0.25 mm×0.25 μm), 2 Rxi-17Sil MS (1.2 m×
 0.15 mm×0.15 μm)
 (Nam *et al.*, 2016)
 (Pegasus 4D-2D TOF system, Leco, MI,
 USA) . 2AP 1, 5, 10
 ppm GC
 (R²)가 0.999

통계처리

3
 SAS 9.2 (SAS Institute Inc.) PC
 package package
 (ANOVA) Duncan (Duncan's multiple
 range test) a=0.05

결과 및 고찰

향미의 품종별,이양시기별 이화학적 특성 평가

1) , 가

Table 2. Comparison for fatty acid of aromatic rice cultivars by transplanting time (n=3)

Transplanting date	Cultivars	Fatty acid content (%) ¹⁾					SF*	USF**
		Palmitic acid (C16:0)	Stearic acid (C18:0)	Oleic acid (C18:1)	Linoleic acid (C18:2)	Linolenic acid (C18:3)		
May 22	Hyangmibyeo 2 ho	20.2±1.5a	1.8±0.1d	43.5±2.5a	33.3±1.6b	1.2±0.1bc	22.0±1.7a	78.0±4.5a
	Aromi	17.1±1.8bc	2.0±0.1c	44.7±3.4a	35.2±2.1ab	1.1±0.1c	19.1±2.1ab	80.9±5.8a
	Mihyang	15.1±1.1c	1.9±0.1cd	45.9±2.8a	35.9±1.8ab	1.1±0.1c	17.0±1.1b	83.0±6.6a
	Aranghyangchal	17.7±0.9ab	2.5±0.1a	41.8±4.1a	36.7±1.2a	1.3±0.1b	20.1±1.4a	79.9±6.4a
	Heughyang	18.3±1.1ab	2.2±0.1b	40.2±2.2a	37.7±1.5a	1.5±0.1a	20.5±1.1a	79.5±5.2a
June 5	Hyangmibyeo 2 ho	19.9±0.8a	1.8±0.1b	42.2±2.5ab	34.8±1.4a	1.4±0.1a	21.7±2.2a	78.3±5.1a
	Aromi	17.9±1.4ab	1.7±0.1b	42.7±2.4ab	36.5±1.5a	1.2±0.1b	19.6±2.1abc	80.4±4.5a
	Mihyang	15.5±0.5c	1.8±0.1b	43.9±2.2ab	37.7±1.5a	1.2±0.1b	17.3±0.2c	82.7±4.9a
	Aranghyangchal	18.9±1.2ab	2.3±0.2a	39.7±3.4b	37.7±2.1a	1.4±0.1a	21.2±1.3ab	78.8±4.4a
	Heughyang	16.7±1.9bc	1.8±0.1b	45.4±1.5a	34.7±1.9a	1.4±0.1a	18.5±0.4bc	81.5±5.4a
June 20	Hyangmibyeo 2 ho	20.6±1.4a	1.3±0.1c	41.6±1.6a	34.8±1.8b	1.7±0.1a	21.9±1.2a	78.1±5.1a
	Aromi	18.1±0.9b	1.6±0.1b	42.8±2.1a	36.3±1.6b	1.2±0.1c	19.7±0.8bc	80.3±4.8a
	Mihyang	17.4±0.4b	1.7±0.1ab	41.8±2.4a	37.8±1.3ab	1.3±0.1c	19.1±0.6c	80.9±4.2a
	Aranghyangchal	20.1±1.1a	1.0±0.1d	37.2±2.1b	40.1±1.8a	1.6±0.1ab	21.1±0.5ab	78.9±4.6a
	Heughyang	17.1±0.9b	1.8±0.1a	43.9±1.7a	35.7±1.6b	1.5±0.1b	18.9±0.9c	81.1±4.1a

*SF: saturated fatty acid, **USF: unsaturated fatty acid

Means in the same column by the same letter are not significantly different at the level of 0.05 by using Duncan's multiple range test

Table 3. Essential amino acid of aromatic rice cultivars by transplanting time (n=3)

Transplanting date	Cultivars	Essential amino acid contents (mg/g)								
		Ile	Leu	Lys	Met	Phe	Thre	Trp	His	Total
May 22	Hyangmibyeo 2 ho	6.7±0.1d	6.2±0.1c	26.4±0.6a	9.5±0.1d	25.4±0.2a	18.3±0.2a	2.1±0.1a	13.4±0.2a	108.1±2.1ab
	Aromi	7.8±0.2b	7.2±0.2a	23.9±0.6c	10.4±0.4c	23.2±0.2cd	18.5±0.1a	2.1±0.1a	10.4±0.2d	103.5±2.4bc
	Mihyang	6.2±0.1e	5.9±0.1d	22.1±0.5d	11.6±0.4a	22.8±0.3d	17.9±0.2b	1.5±0.1c	11.5±0.2c	99.5±3.1c
	Aranghyangchal	7.2±0.1c	6.8±0.1b	23.4±0.3c	10.5±0.1c	23.6±0.3c	17.9±0.1b	1.9±0.1b	10.4±0.2d	101.7±3.5c
	Heughyang	8.5±0.2a	7.4±0.1a	25.1±0.4b	11.1±0.1b	24.1±0.2b	18.4±0.2a	2.2±0.1a	12.4±0.1b	109.2±2.8a
June 5	Hyangmibyeo 2 ho	6.5±0.1d	6.4±0.1bc	28.4±0.3a	9.8±0.1d	22.1±0.1a	16.3±0.2ab	2.0±0.1c	12.5±0.1a	104.1±1.9a
	Aromi	7.7±0.2b	7.2±0.1a	24.8±0.2c	10.4±0.1c	21.8±0.3ab	16.4±0.1a	2.4±0.1a	10.4±0.2c	101.1±2.1ab
	Mihyang	6.7±0.1cd	6.2±0.2c	23.9±0.4d	11.4±0.4b	18.4±0.3c	16.1±0.1b	1.6±0.1e	11.6±0.1b	95.9±1.8c
	Aranghyangchal	6.9±0.1c	6.6±0.1b	24.5±0.4cd	12.1±0.5a	21.4±0.2b	15.6±0.1c	1.8±0.1d	10.5±0.1c	99.4±1.6bc
	Heughyang	8.4±0.2a	7.3±0.1a	25.8±0.5b	10.3±0.2cd	22.1±0.4a	16.2±0.1ab	2.2±0.1b	11.4±0.2b	103.7±2.2a
June 20	Hyangmibyeo 2 ho	6.6±0.2d	6.5±0.1b	26.5±0.3a	9.9±0.1c	20.6±0.2a	16.2±0.1c	2.1±0.1a	11.1±0.2b	99.5±2.2ab
	Aromi	7.6±0.2b	7.2±0.1a	24.5±0.2b	10.3±0.1bc	20.4±0.2a	17.3±0.1a	2.1±0.1a	11.4±0.1b	100.8±2.8ab
	Mihyang	6.4±0.2d	6.1±0.1c	23.8±0.4c	10.6±0.4b	16.9±0.1d	16.8±0.1b	1.8±0.1b	11.3±0.2b	93.7±2.4c
	Aranghyangchal	7.1±0.1c	6.2±0.1c	22.2±0.2d	11.6±0.3a	20.1±0.1b	15.8±0.2d	1.8±0.1b	11.8±0.2a	96.6±2.3bc
	Heughyang	8.9±0.2a	7.4±0.2a	24.2±0.2bc	10.5±0.1b	19.8±0.1c	17.2±0.2a	2.2±0.1a	12.1±0.1a	102.3±2.1a

Means in the same column by the same letter are not significantly different at the level of 0.05 by using Duncan's multiple range test.

Table 3
 93.7~ 99.5 mg/g 가 , Mihyang
 ~ 109.2 mg/g 가 , Heughyang 가 102.3
 104.4 mg/g,

(Yoon *et al.*, 2016).

mg/g	100.8 mg/g, 가	99.8	65~70°C	Hyangmibyeo 2 ho가 가
			(Peak, P)	Hyangmibyeo 2 ho, Aromi
			279.3, 258.8 RVU	Aranghyangchal
			71.7 RVU 가	(Final viscosity)
			가 가	Arom이가 255.3 RVU 가
Hyangmibyeo 2 ho			Aranghyangchal	42.7 RVU 가
			(Breakdown)	가
			(shear)	
			가	(Kim <i>et</i>
신속점도측정기(RVA)에 의한 호화 특성			al., 2012).	Hyangmibyeo 2 ho가 152.3 RVU
			가	Aranghyangchal 38.4 RVU 가
	RVA	(Peak),	(Setback)	Hyangmibyeo
(Breakdown)	가	가	가	Heughyang 39.4 RVU
	가			Hyangmibyeo 2 ho 가
(Sonet <i>al.</i> , 2002). Table 3				
RVA				Aranghyangchal
5				201.1~279.3 RVU
Heughyang, Aranghyangchal, Mihyang,				185.9~262.2 RVU,
Aromi, Hyangmibyeo 2 ho	70.1, 71.3, 73.6,	RVU		194.8~234.4
73.7, 74.1°C	가	가		66.6~152.3 RVU
				64.1~140.1 RVU,
				55.4~113.6

Table 4. Pasting properties of aromatic rice cultivars by transplanting time using RVA (n=3)

Transplanting date	Cultivars	Initial pasting temperature (°C)	Viscosity (RVU) ¹⁾				
			Peak (P)	Trough (T)	Final viscosity	Breakdown (P-T)	Setback
May 22	Hyangmibyeo 2 ho	74.1±0.05a	279.3±0.2a	126.9±0.2d	199.4±1.5d	152.3±10.5a	-78.9±8.2e
	Aromi	73.7±0.03b	258.8±0.2b	156.7±0.5a	255.3±1.4a	102.1±2.5b	-3.5±1.5b
	Mihyang	73.6±0.08c	249.1±0.3c	142.3±0.5b	231.8±2.5b	106.8±1.4b	-17.2±2.6c
	Aranghyangchal	71.3±0.05d	105.6±0.2e	50.1±0.3e	63.9±2.5e	55.5±1.2d	-41.6±1.9d
	Heughyang	70.1±0.03e	201.1±0.4d	134.6±0.4c	218.1±3.8c	66.6±1.0c	17.0±1.4a
June 5	Hyangmibyeo 2 ho	72.2±0.06a	262.2±0.3a	122.1±0.4c	201.8±3.2b	140.1±12.8a	-60.4±2.2e
	Aromi	71.8±0.03b	235.9±0.3c	150.2±0.6b	249.8±3.5a	85.7±4.5b	13.8±0.5b
	Mihyang	71.8±0.02b	240.4±0.2b	156.3±0.4a	245.2±2.8a	84.2±2.1b	4.8±0.1c
	Aranghyangchal	69.2±0.02c	71.7±0.2e	33.4±0.5d	42.7±1.5c	38.4±1.9d	-19.0±0.5d
	Heughyang	69.1±0.04d	185.9±0.2d	121.8±0.5c	207.3±4.8b	64.1±1.4c	21.4±0.8a
June 20	Hyangmibyeo 2 ho	68.2±0.02d	234.4±0.5a	120.8±0.6d	218.4±4.3c	113.6±6.5a	-16.1±1.4c
	Aromi	70.2±0.05b	223.3±0.6b	136.4±0.7b	241.7±5.1a	86.8±1.7b	18.4±1.1b
	Mihyang	70.5±0.03a	207.3±1.1c	132.8±0.5c	224.1±4.1c	74.5±5.1c	16.8±0.5b
	Aranghyangchal	68.0±0.02e	90.1±0.5e	32.9±0.6e	43.6±0.5d	57.2±2.2d	-46.5±3.3d
	Heughyang	68.8±0.02c	194.8±0.8d	139.4±0.8a	234.3±3.3b	55.4±0.9d	39.4±1.8a

Means in the same column by the same letter are not significantly different at the level of 0.05 by using Duncan's multiple range test.

¹⁾RVU: Rapid Visco Units

RVU 199.4~255.3
 RVU 201.8~249.8 RVU, 218.4
 ~241.7 RVU -78.9~
 17.0 RVU -60.4~21.4 RVU,
 -46.5~39.4 RVU
 Hyangmibyeo 2 ho, Aromi가
 가 가

향미 품종,이양시기별향기성분 정량 분석 비교

(Buttery *et al.*, 1988).

가
 가가
 가 2-acetyl-1-
 pyrroline (2AP) GC
 GC-MS Fig. 2 2AP
 GC-MS 152.3RVU 가
 Aromi가 41.7~66.7 µg/100 g 가 2AP
 Mihyang 10.5~22.1 µg/100 g 가
 가 2AP
 37.4
 µg/100 g, 31.5 µg/100 g, 37.4
 µg/100 g 2AP가
 6 5~20
 Kim (2008) 2AP
 가 2AP

가

가

Aromi 2AP
 GC-MS

가

적 요

1. 가

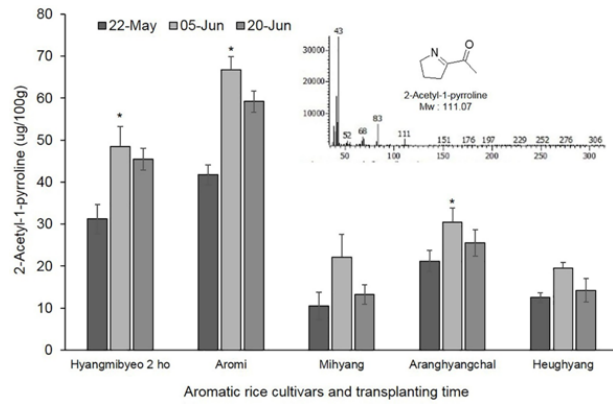


Fig. 2. 2AP contents of aromatic rice cultivars by transplanting time and GC-MS fragmentation pattern of 2AP.

5.8~7.3% 5 22 6.4%
 가 2.6±0.1%,
 2.5±0.1%, 2.2±0.1%
 가
 2. Hyangmibyeo 2 ho가
 152.3RVU 가 가
 가
 3. 2-acetyl-1-pyrroline (2AP)
 Aromi
 가 41.7~66.7 µg/100 g 가 2AP
 37.4 µg/100 g, 31.5 µg/100 g,
 37.4 µg/100 g
 6 5~20

Notes

The author declare no conflict of interest.

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