Korean J. Plant Res. 28(6):734-742(2015)
http://dx.doi.org/10.7732/kjpr.2015.28.6.734

Print ISSN 1226-3591
Online ISSN 2287-8203

Original Research Article

Flavor Characteristics and Consumer Acceptance of Yacon (*Smallanthus sonchifolius* Poepp & Endl) Leaf Tea by Different Processes

Dong Young Shin[1]*, Kyu Hwan Hyun[1], Yong In Kuk[1], Dong Won Shin[1] and Soon Sil Chun[2]

[1]Department of Development in Oriental Medicine Resources, Sunchon National University, Suncheon 57922, Korea
[2]Department of Food and Nutrition, Sunchon National University, Suncheon 57922, Korea

Abstract - The purpose of this research was to find the most appropriate process for making yacon leaf tea. We applied both green tea and black tea brewing and fermenting methods for producing yacon leaf tea. This research included consumer test and descriptive analysis of professional trained panel on yacon tea tastes and flavors. Both consumer test and descriptive evaluation preferred yacon tea produced by black tea brewing and fermenting methods because it tasted less bitter and had a sweet, delicate taste. According to orthogonal transformation resulting from varimax rotation, first principal component was positively affected by black tea brewing and fermenting methods, while it was negatively affected by green tea brewing and fermenting methods. As a result, the study concluded black tea brewing and fermenting methods were appropriate for producing yacon leaf tea.

Key words - Yacon (*Smallanthus sonchifolius* Poepp& Endl), Leaf tea, Consumer test, Descriptive analysis

Introduction

Tea is a popular beverage and has been widely consumed for various purposes including healing, thirst quenching, and refreshment. The tea industry is one of the major international industries and has secured a stable production and consumption market with various tea products. Nowadays, tea products are expected to function as a healthy supplementary beverage. Yacon (*Smallanthus sonchifolius* Poepp& Endl) is belong to Compositae family and annual tuber plant. Originally from Aqua Dore of South America (Fernandez *et al*., 2006), it was imported and cultivated in Korea since 1985 (Kim *et al*., 2010).

The tuber roots of yacon are similar to sweet potatoes in appearance but have a juicy and soft texture similar to pears and are also known as 'Pears of the underground'. Yacon leaves are reported to have beneficial effects on diabetes (Aybar *et al*., 2001; Padilha *et al*., 2009; Kim *et al*., 2010) as well as for pre-diabetic patients. In animal studies, extracts from dried yacon leaf tea reduced sugar levels of diabetic mouse (Kim *et al*., 2010). It may also be effective for constipation by activating intestinal peristalsis (Geyer *et al*., 2008) with increasing bifid bacterium and decreasing poisoning bacteria. In addition, some reports showed that yacon may prevent arteriosclerosis (Valentova *et al*., 2005). The yacon leaves are used to make infusions and pills for lowering cholesterol (Scheid *et al*., 2014). Yacon is a low calorie food whose carbohydrates are not easily digested, and thus, yacon tubers are good for diabetes (Genta *et al*., 2009). It is the main ingredient used to make syrup for diabetic patients (Genta *et al*., 2009).

There is growing interest in this crop worldwide and commercialization has increased significantly over the past decade (Fernández *et al*., 2006). Although small-scale production dominates, exports of yacon products to Japan, the European Union, and the United States are increasing from Korea. There are many yacon products using the root such as yacon juice, tea, pellets, and mill, but yacon leaves were discarded.

The quality and characteristics of tea are determined by different processing methods (Wang *et al*., 2000). Teas can be classified into two groups, basic tea and reprocessed tea. After cutting, the yacon leaves were fermented for 12 hours to reduce its bitter taste, changing from fresh to fruit aromas and flavors. Changes in the chemical and sensory quality parameters of black tea were due to variations of fermentation time and

*Corresponding author. E-mail : sdy@sunchon.ac.kr
Tel. +82-61-750-3284

temperature (Obenda *et al*., 2001). The major constituent of tea's aroma is a fragrant substance that exists in fresh tea leaves and differs from the tea making process (Lee *et al*., 2014). The purpose of this research was to determine the influence of green tea and black tea methods on the flavor and taste of yacon leaf tea.

Materials and Methods

Yacon leaves were harvested on 29th September, 2012 from the Farm Center of Sunchon National University. Adjustments were made to the yacon tea making process by two different basic and fermented tea making methods. The yacon leaf tea was prepared by the green tea and black tea manufacturing methods described by Wang *et al*. (2000).

Yacon leaf tea using black tea manufacturing method

Yacon leaves were harvested and any foreign matter was removed. After sorting the cutting mill, they were shacked on a wide bamboo basket. After drying off any moisture, they were rubbed between the palms of the hands and then were shaken until they no longer clumped together. Firstly, rolling was accomplished by a rolling machine to change components. To remove the bitter taste, the leaves were dried in outdoor, under sunlight for 30 minutes. Fermented yacon leaves were poured into an iron pot, pre-heated at 300℃, and then, cooked quickly and thoroughly to disintegrate enzymes and loosen fibers. The leaves were then allowed to cool down for 10 to 20 minutes. After a second rolling, the leaves were dried in the drying chamber at 55℃ for seven hours. Afterwards, dried leaves were divided into two portions, one sample was again dried at 100℃, which was labeled as FYH (Fermented Yacon Tea). The other sample was again dried at 80℃ and was labeled as FYL (Fermented Yacon Tea Enhancing Flavor in Low Temperature). Afterwards, dried yacon leave tea were packed into laminated aluminum pouch of 30g per bag.

Yacon leaf tea using green tea manufacturing method

After harvesting, the yacon leaves were sliced by cutting mill. An iron was pre-heated to about 300℃ and then, the yacon leaves were poured in and cooked quickly in order to disintegrate enzymes and loosen fibers. The leaves were allowed to cool for 20 minutes to preserve the color of the green leaves. After drying off any moisture, the leaves were rubbed between the palms of the hands to bring out the taste of yacon leaves and then, were shaken until they no longer clumped together. The stir frying and rubbing were repeated twice until the moisture of the leaves spread. The tea leaves were dried at 55℃ for seven hours to prevent degradation. The leaves were dried until the moisture content had been reduced to 4%. Dried leaves were divided into two samples. Yacon leaves was poured into a hot pot at 80℃ then dried for two hours and 30 minutes: GYL (Green Yacon Tea Enhancing in Low Temperature). Treatment No.4 was drying yacon leaves were dried at 100℃ for two hours: Green Yacon Tea Enhancing in High Temperature (GYH). To compare the samples to the product on sale in Jo Tae-Hyun Tea Co., the product was labeled as JTH and was used in this study. Treatment samples were packed in aluminum pouch of 30 g per bag.

Yacon tea preparation for consumer test

To prepare and demonstrate the yacon tea sample, 1 g of tea was extracted from 70℃ water for one minute. Porcelain pots were used for brewing samples. To minimize the carry-over effect during the test, water and hard biscuits were provided and consumers were encouraged to rinse their palate between tasting each sample.

A total of 47 students of the Department of Plant Resources in Sunchon National University participated in this study. Consumers who were willing to taste yacon leaf tea and had no allergies to foods or medication were recruited and compensated for their time. As yacon leaf tea was unfamiliar beverage at the time of evaluation, consumers did not have to be yacon tea drinkers. Consumers evaluated five samples by Complete Block Design. Consumers were given five minutes to evaluate each sample.

Consumers evaluated yacon leaf tea samples for acceptability and preference for the strength of flavor using a 9-point hedonic scale with anchors from dislike extremely to like extremely. Neutral was also indicated as neither like nor dislike. The evaluations were made on color, flavor, good throat swallowing, and overall acceptability. The categories for intensity of characteristics were astringency, bitter taste,

sweet taste, delicate flavor, and yacon redolence. The consumers were also asked to rate the intensity of the overall flavor and bitterness using a 9-point intensity scale, with anchors from none to extreme.

A total of five yacon leaf tea samples from five different processes were selected for the tea preparation of loose yacon tea leaf samples. Each 1 g of yacon tea leaf was extracted by reverse osmosis in 200 ㎖ de-ionized, carbon-filtered water at 70℃ and brewed for one minute in porcelain pots. During infusion, the pot was swirled clockwise ten times. The yacon tea was poured into a warmed bowl through a porcelain strainer.

Yacon leaf tea preparation for highly trained panelists test

Yacon leaf tea samples from the refrigerator were removed at least one hour before brewing and were allowed to reach the room temperature. Then, each yacon leaf tea sample was weighed 4.0 g and set aside for brewing for each "pot" of tea. To brew yacon leaf tea, 600 ㎖ of drinking water (Nestlé pure life) was heated to 70℃; and then, was poured small amounts into the white porcelain teapot (approximately 700 ㎖ in volume), the teacups (100 ㎖ in volume), and the beaker to warm the containers. Five highly trained panelists from the sensory center at Kasetart University served as the panel in this study. The standardized yacon leaf tea aroma and flavor lexicon was used for the descriptive analysis in this study. The yacon leaf tea was brewed for two minutes and while being brewed, the teapot was swirled ten times in clockwise. Later, the yacon leaf tea was poured through the porcelain strainer into the pre-warmed beaker; and then, into the pre-warmed, 45 ㎖ teacups.

Descriptive analysis of yacon leaf tea

Descriptive analysis of yacon leaf tea was based on modified method of Lee and Chambers (2007, 2010).

Results and Discussion

The fermented processed leaf color was denser than in basic processing methods. Non-fermented leaves have a fresh green aroma. Yacon leaves with the fermented process can develop even flavors and aromas with good quality. That is ideal for prolonged shelf life and is good for exchange and storage. Flavonoid and sensory qualities of green tea beverages depend on heat processing and storage (Wang *et al*., 2000). A final drying is done to prevent degradation and to add flavor and aroma yacon leaves were repeatedly stir-fried and rubbed for two to three times until the moisture of the leaves was spread to 3~4%.

Consumer hedonic test

Table 1 presents consumer acceptance of 5 different yacon leaf teas. Total of 47 consumers from Sunchon National University participated in this study. The most favorable sample was number FYH by the entire panel. Color from the fermented process of adding flavor had the best score of 6.51

Table1. Consumer acceptance test of 5 different yacon leaf tea

Sample	Yacon leaf tea				
	JTH[z]	FYH[y]	FYL[x]	GYL[w]	GYH[v]
Color	5.81 ± 1.95[u]	6.51 ± 1.25NS[t]	6.47 ± 1.47	6.34 ± 1.54	5.89 ± 1.77
Flavor	4.00 ± 1.81b[s]	5.32 ± 1.93a	4.53 ± 1.83b	4.40 ± 1.62b	4.17 ± 1.74b
Good throat	3.89 ± 1.82b	5.38 ± 1.76a	5.23 ± 1.67a	4.26 ± 1.52b	4.32 ± 1.75b
Overall acceptability	3.70 ± 1.86c	5.13 ± 1.66a	4.66 ± 1.74ab	4.28 ± 1.74bc	3.96 ± 1.61bc

[z]JTH: The product on sale in Jo Tae-Hyun Tea Co.
[y]FYH: Fermented Yacon Tea Enhancing Flavor in High Temperature.
[x]FYL: Fermented Yacon Tea Enhancing Flavor in Low Temperature.
[w]GYL: Green Yacon Tea Enhancing Flavor in Low Temperature.
[v]GYH: Green Yacon Tea Enhancing Flavor in High Temperature.
[u]Values are mean ± standard deviation (n = 47).
[t]N S: Not significantly.
[s]Means with the same superscripts in each row are not significantly different by Duncan' multiple range test ($p < 0.05$).

and JTH was 5.81, but there was no significant difference among the samples. Flavor of FYH was 5.32, being the highest among the samples. For Good throat, FYH and FYL did not have significant difference; and also, GYL, GYH, and JTH did not have significant difference. Referring to the overall acceptability, the fermented samples, FYH and FYL, had 5.13 and 4.66, respectively. The samples, GYL, GYH, and JTH, had 4.28, 3.96, and 3.70, respectively. The fermented samples had a higher acceptability than the green yacon leaf tea samples and between them. FYH had the highest overall acceptability.

Contents of Table 2 represents intensity of yacon leaf tea based on 5 different processing. In astringency, JTH rated 5.55, while FYH scored 4.49, which was slightly lower than GYL and GYH. JTH scored 6.38, while FYH scored 5.66, being the bitterest and the least bitter taste, respectively. For sweetness, FYH had the highest score of 2.74 and JTH had the least score of 2.60. In other words, even if there were no significant statistical differences on astringency, bitter taste, and sweet taste among the 5 samples, the samples of FYH and FYL showed lower rate in astringency and bitter taste, while scored higher in sweet taste.

For delicate taste, the samples, FYL, JTH, GYL, and GYH did not show significant statistical difference, while FYH scored higher than FYL in delicate taste, scoring 4.57. For yacon redolence, there were significant statistical differences among 5 samples. However, the fermented yacon leaf tea samples rated higher than green yacon tea samples.

Summarizing Table 2 data, the yacon leaf fermented process of enhancing flavor was better than the green tea making process in color, flavor, good throat, and lower in astringency and bitter taste. Also, a sweeter taste and more delicate taste showed in the yacon leaf teal produced by black tea manufacturing process. According to Obenda *et al*. (2001), chemical quality effects of processing parameters depend on fermentation temperature and duration. In our study, FYL tea in our study showed similar results to the study. Consequently, the unique flavor of yacon leave tea had less popularity among consumers, but the fermented and enhancing flavor process can promote the consumer's taste preference.

Table 3 shows the means of attributes, appearance and aroma, of 5 different yacon leaf teas. The attributes of appearance were yellowness and tubidity. For tubidity, there were no significant statistical differences among the 5 samples. However, for yellowness, the samples of GYL, GYH, and JTH scored higher than the samples of FYH and FYL.

The result of final drying process of GYL and GYH had more reduced fresh green aroma than processed FYH and FYL. Fermented processing by methods FYH, FYL has a high degree of seaweed and spinach aromas.

To reduce the unique yacon fresh aroma, a fermented processing method is necessary. Drying off the moisture of yacon leaves, the fermentation process of enhancing flavor brings out the taste of yacon and it increases the quality of

Table 2. Intensity of yacon leaf tea by 5 different yacon leaf tea

Attributes	Samples				
	JTH[z]	FYH[y]	FYL[x]	GYL[w]	GYH[v]
Astringency	5.55 ± 2.87[u]	4.49 ± 2.54NS[t]	4.74 ± 2.62	5.21 ± 2.41	5.23 ± 2.58
Bitter taste	6.38 ± 2.48	5.66 ± 2.20NS	5.79 ± 2.54	6.11 ± 2.39	6.23 ± 2.41
Sweet taste	2.60 ± 1.93	2.74 ± 1.89NS	2.55 ± 1.87	2.34 ± 1.71	2.43 ± 1.69
Delicate teste	3.60 ± 2.12b[s]	4.57 ± 2.14a	3.98 ± 2.02ab	3.64 ± 1.95b	3.53 ± 1.74b
Yacon redolence	5.70 ± 1.79ab	5.79 ± 1.67a	5.23 ± 1.78abc	4.98 ± 1.62bc	4.60 ± 1.73c

[z]JTH: The product on sale in Jo Tae-Hyun Tea Co.
[y]FYH: Fermented Yacon Tea Enhancing Flavor in High Temperature.
[x]FYL: Fermented Yacon Tea Enhancing Flavor in Low Temperature.
[w]GYL: Green Yacon Tea Enhancing Flavor in Low Temperature.
[v]GYH: Green Yacon Tea Enhancing Flavor in High Temperature.
[u]Values are mean ± standard deviation (n = 47).
[t]N S: Not significantly.
[s]Means with the same superscripts in each row are not significantly different by Duncan' multiple range test ($p < 0.05$).

Table 3. The means of attributes (appearance and aroma) of 5 different yacon leaf tea

Attributes	Sample				
	JTH[z]	FYH[y]	FYL[x]	GYL[w]	GYH[v]
Appearance					
Yellowness	12.30a[u] ± 0.00	11.65b ± 0.21	6.25c ± 0.35	12.25a ± 0.07	12.70a ± 0.00
Tubidlty[NS]	1.30 ± 0.00	1.40 ± 0.14	1.15 ± 0.21	1.30 ± 0.00	1.15 ± 0.21
Aroma					
A-Green	1.50b ± 0.42	2.50a ± 0.00	2.85a ± 0.21	1.35b ± 0.21	1.40b ± 0.14
A-Celery[NS]	1.00 ± 0.00	1.50 ± 0.00	1.30 ± 0.14	1.35 ± 0.21	1.35 ± 0.49
A-Spinach	0.00b ± 0.00	1.10a ± 0.14	1.25a ± 0.35	0.75a ± 0.35	0.00b ± 0.00
A-Parsley[NS]	0.00 ± 0.00	0.75 ± 0.35	0.90 ± 0.14	0.40 ± 0.57	0.25 ± 0.35
A-Brown[NS]	2.75 ± 0.35	2.40 ± 0.14	2.30 ± 0.14	2.80 ± 0.28	2.65 ± 0.49
A-Burnt[NS]	1.20 ± 0.28	1.20 ± 0.00	0.75 ± 0.07	1.60 ± 0.14	1.30 ± 0.28
A-Ashy	1.25a ± 0.07	1.00ab ± 0.00	0.60b ± 0.14	1.35a ± 0.07	1.25a ± 0.35
A-Tobacco	3.25a ± 0.07	2.10b ± 0.14	1.25c ± 0.35	2.80a ± 0.28	3.35a ± 0.21
A-Straw like[NS]	1.25 ± 0.07	1.30 ± 0.00	0.85 ± 0.21	1.25 ± 0.07	1.45 ± 0.21
A-Seaweed	0.00b ± 0.00	1.00a ± 0.00	0.95a ± 0.07	0.00b ± 0.00	0.00b ± 0.00
A-Dried banana leaf[NS]	2.20 ± 0.00	2.25 ± 0.35	2.00 ± 0.00	2.00 ± 0.42	2.20 ± 0.00
A-Dry[NS]	2.00 ± 0.00	2.05 ± 0.35	1.90 ± 0.14	2.35 ± 0.21	2.10 ± 0.14
A-Musty[NS]	0.50 ± 0.00	0.50 ± 0.00	0.50 ± 0.00	0.70 ± 0.00	0.60 ± 0.14
A-Sweet aromatic[NS]	1.20 ± 0.00	1.20 ± 0.14	0.90 ± 0.14	1.00 ± 0.00	1.00 ± 0.00

[z]JTH: The product on sale in Jo Tae-Hyun Tea Co.
[y]FYH: Fermented Yacon Tea Enhancing Flavor in High Temperature
[x]FYL: Fermented Yacon Tea Enhancing Flavor in Low Temperature
[w]GYL: Green Yacon Tea Enhancing Flavor in Low Temperature
[v]GYH: Green Yacon Tea Enhancing Flavor in High Temperature
[u]Means with the same superscripts in each row are not significantly different by Duncan's multiple range test ($p < 0.05$).

color, flavor, and aroma.

Descriptive analysis of yacon tea's fourteen attributes from a green tea lexicon developed by Lee and Chambers (2007; 2010), were used to describe the five yacon leaf tea samples in Table 3: green, celery, spinach, parsley, brown, burnt, ashy, tobacco, straw-like, seaweed, dried banana leaf, dry, mushy, and sweet aromatic. Except A-Green, A-Spinach, A-Ashy, A- Tobacco, and A-Seaweed, other 9 attributes did not have significant statistical differences. For A-Green, A-Spinach, and A-Seaweed, the samples of FYH and FYL scored higher than the other three samples. However, for A-Ashy and A-Tobacco, the samples of GYL, GYH, and JTH scored higher than the samples of FYH and FYL. In other words, the black tea manufacturing method reduced the aroma of ashy and tobacco.

Table 4 presents the mean intensity of twelve sensory flavors of 5 different yacon leaf teas. The twelve sensory flavors were green, celery, spinach, parsley, brown, burnt, ashy, tobacco, straw like, seaweed, and dried banana leaf. The samples of FYH and FYL scored higher than the samples of GYL, GYH, and JTH in F-green, F-spinach, F-parsley, and F-seaweed. However on the other hand, the samples of GYL, GYH, and JTH scored higher than the samples of FYH and FYL in F-Celery, F-Brown, F-Tobacco, and F-Sraw like. Among 5 yacon tea samples, there were no significant statistical differences in F-Ashy, F-Dried banana leaf, and F-Musty.

As shown in Table 5 the mean intensity of sensory attributes of 5 different yacon leaf teas: taste, chemical feeling, and after taste. The taste attributes are bitter and sweetness. The chemical feel was astringent and toothache. The after-taste has six attributes, which are bitter, green, celery, ashy, tobacco, and dried banana leaf. Among 10 indicators of sensory attributes, astringent, tooth-etch, AF-Green, AF-Ashy, AF-Tobacco, and

Table 4. The mean intensity of twelve sensory flavors of 5 different yacon leaf tea

Attributes		Sample				
		JTH[z]	FYH[y]	FYL[x]	GYL[w]	GYH[v]
Flavor	F-Green	1.80c[u] ± 0.42	3.00a ± 0.28	2.70ab ± 0.14	1.85c ± 0.21	2.10bc ± 0.14
	F-Celery	1.15bc ± 0.21	1.65ab ± 0.21	1.00c ± 0.00	2.00a ± 0.28	1.65ab ± 0.21
	F-Spinach	0.00c ± 0.00	1.00ab ± 0.00	1.35a ± 0.49	1.10ab ± 0.14	0.40bc ± 0.57
	F-Parsley	0.00c ± 0.00	0.60ab ± 0.14	0.85a ± 0.21	0.00c ± 0.00	0.25bc ± 0.35
	F-Brown	3.40a ± 0.14	2.60bc ± 0.14	1.95c ± 0.49	2.75ab ± 0.35	2.75ab ± 0.07
	F-Burnt	1.55ab ± 0.07	1.50b ± 0.14	1.35b ± 0.07	1.75a ± 0.07	1.45b ± 0.07
	F-Ashy[NS]	1.30 ± 0.00	1.10 ± 0.14	0.85 ± 0.21	1.35 ± 0.21	1.20 ± 0.00
	F-Tobacco	3.40a ± 0.14	1.75b ± 0.35	1.65b ± 0.21	3.30a ± 0.00	3.35a ± 0.07
	F-Straw like	1.55 ± 0.21	1.30 ± 0.00	1.25 ± 0.35	1.25 ± 0.07	1.40 ± 0.14
	F-Seaweed	0.00b ± 0.00	0.85a ± 0.21	1.00a ± 0.00	0.00b ± 0.00	0.00b ± 0.00
	F-Dried banana leaf[NS]	2.15 ± 0.21	2.20 ± 0.00	2.00 ± 0.00	2.30 ± 0.00	2.15 ± 0.21
	F-Musty[NS]	0.55 ± 0.07	0.50 ± 0.00	0.25 ± 0.35	0.50 ± 0.00	0.50 ± 0.00

[z]JTH: The product on sale in Jo Tae-Hyun Tea Co.
[y]FYH: Fermented Yacon Tea Enhancing Flavor in High Temperature.
[x]FYL: Fermented Yacon Tea Enhancing Flavor in Low Temperature.
[w]GYL: Green Yacon Tea Enhancing Flavor in Low Temperature.
[v]GYH: Green Yacon Tea Enhancing Flavor in High Temperature.
[u]Means with the same superscripts in each row are not significantly different by Duncan's multiple range test ($p < 0.05$).

Table 5. The mean intensity of sensory attributes (taste, chemical feeling, after taste) of 5 different yacon leaf tea

Attributes		Sample				
		JTH[z]	FYH[y]	FYL[x]	GYL[w]	GYH[v]
Taste	Bitter	11.25a[u] ± 0.07	10.65a ± 0.21	9.40c ± 0.57	9.85bc ± 0.21	10.60ab ± 0.14
	Sweetness	0.60 ± 0.14	0.50 ± 0.00	0.50 ± 0.00	0.60 ± 0.14	0.60 ± 0.14
Chemical feeling	Astringent[NS]	1.10 ± 0.00	0.90 ± 0.14	0.75 ± 0.07	0.95 ± 0.07	0.95 ± 0.07
	Tooth-etch[NS]	1.55 ± 0.21	1.20 ± 0.00	1.25 ± 0.07	1.15 ± 0.21	1.25 ± 0.07
Aftertaste	AF-Bitter	7.50a ± 0.00	6.75b ± 0.35	5.50c ± 0.00	6.35b ± 0.21	6.70b ± 0.14
	AF-Green[NS]	0.50 ± 0.00	0.90 ± 0.14	1.00 ± 0.00	0.75 ± 0.35	0.85 ± 0.21
	AF-Celery	0.50c ± 0.00	0.75b ± 0.07	0.50c ± 0.00	0.70b ± 0.00	1.00a ± 0.00
	AF-Ashy[NS]	0.75 ± 0.07	0.50 ± 0.00	0.45 ± 0.07	0.65 ± 0.21	0.85 ± 0.21
	AF-Tobacco[NS]	1.30 ± 0.00	1.00 ± 0.00	0.75 ± 0.35	1.20 ± 0.28	1.10 ± 0.14
	AF-Dried banana leaf[NS]	1.10 ± 0.14	1.15 ± 0.21	0.70 ± 0.00	1.00 ± 0.00	1.10 ± 0.14

[z]JTH: The product on sale in Jo Tae-Hyun Tea Co.
[y]FYH: Fermented Yacon Tea Enhancing Flavor in High Temperature.
[x]FYL: Fermented Yacon Tea Enhancing Flavor in Low Temperature.
[w]GYL: Green Yacon Tea Enhancing Flavor in Low Temperature.
[v]GYH: Green Yacon Tea Enhancing Flavor in High Temperature.
[u]Means with the same superscripts in each row are not significantly different by Duncan's multiple range test ($p < 0.05$).

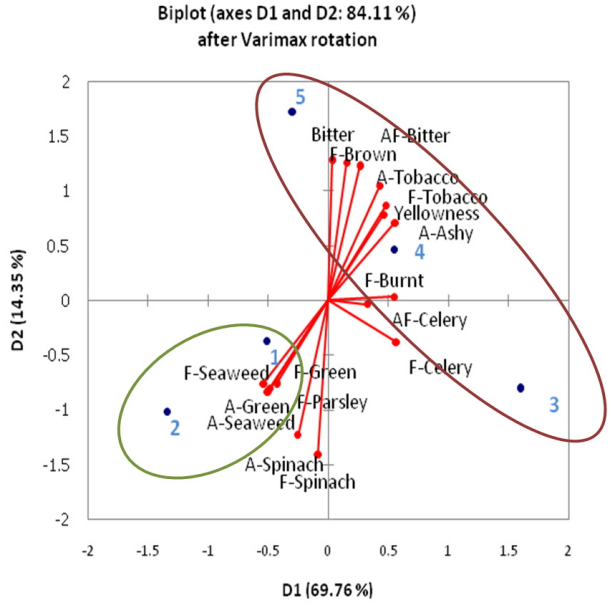
AF-Dried banana leaf did not have significant statistical differences among the 5 different samples. However, the high-trained panelists scored FYL higher than FYH in bitter and AF-Bitter, while consumers scored FYH higher than FYL in bitter and AF-Bitter (Fig. 3).

The result of PCA (Principal Component Analysis) and factor loadings is shown as positive and negative effects in Table 6. Factor loading is to clarify the relation of each factor

Table 6. Principal factor matrix after orthogonal factor loadings: rotation for 17 items in 5 different yacon leaf tea

Attributes	F1	F2	F3
Yellowness	0.889*[z]	0.109	0.422
A-Green	-0.965*	-0.206	0.114
A-Spinach	-0.879*	0.337	0.037
A-Ashy	0.956*	0.247	0.114
A-Tobacco	0.983*	-0.055	0.106
A-Seaweed	-0.923*	-0.125	0.300
F-Green	-0.839*	-0.086	0.529
F-Celery	0.429	0.796*	0.411
F-Spinach	-0.788*	0.605	-0.046
F-Parsley	-0.957*	-0.135	0.197
F-Brown	0.898*	-0.323	0.031
F-Burnt	0.615	0.575	-0.133
F-Tobacco	0.951*	0.089	-0.241
F-Seaweed	-0.964*	-0.130	0.185
Bitter	0.671	-0.599	0.392
AF-Bitter	0.790*	-0.458	0.280
AF-Celery	0.341	0.370	0.671*

[z]Values are the nearest intgar values greater than 0.671 have been flaged by an. '*'



1. JTH: The product on sale in Jo Tae-Hyun Tea Co.
2. FYH: Fermented Yacon Tea Enhancing Flavor in High Temperature.
3. FYL: Fermented Yacon Tea Enhancing Flavor in Low Temperature.
4. GYL: Green Yacon Tea Enhancing Flavor in Low Temperature.
5. GYH: Green Yacon Tea Enhancing Flavor in High Temperature.

Fig. 1. Principal component biplot explained 84.11% of total variables.

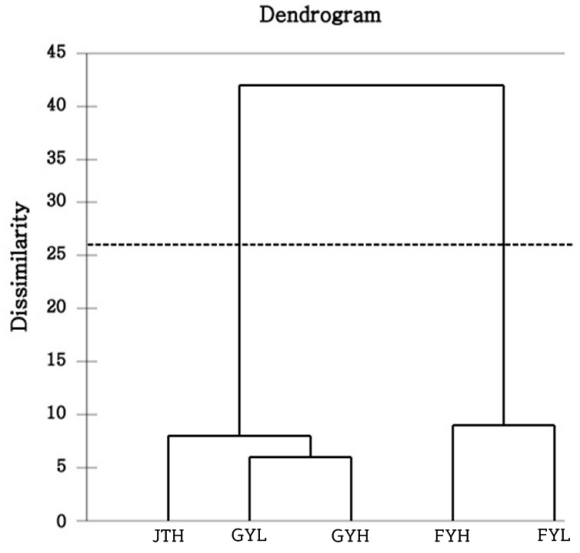
and 17 items by orthogonal varimax rotation. Positive factors affected F1 loadings are yellowness, A-Ashy, AF-Tobacco, F-Brown, and AF-Bitter taste. These are related to the black tea making process. Negative factors are A-Green yacon tea making process. These results show clearly that the characteristics of factors are different and link them here. The rate range of F1 in positive factor loading was 0.790 to 0.983 and negative factor loading was down to −0.788 to -0.965. Also, only F-Celery affected positively on F2 factor loading and the score was 0.796. AF-Celery also affected positively in F3 with a score of 0.671.

The variables, observations, and bi-plot based on PCA score in sensory test are shown in Figure 1. Factor component 1 explained 69.76% of data variability and Factor component 2 explained 14.35%. FYH and FYL are in the 3rd quadrant and GYL and GYH are in the 1st quadrant. In the 1st quadrant, three samples are placed near F-Celery, F-Burnt, and AF-Celery; and GYH samples are placed near A-Ashy, F-Tobacco, and yellowness. JTH is located in 4th quadrant and placed near F-Brown, AF-Bitter, and bitter. It has a very clear division within three groups: black tea made method, green tea made method, and the others.

Fig. 1 Shows the results from factor loadings after the varimax Rotation. The varimax Rotation method is to clarify the positive and negative effects of grouping factors (Shin & Nou 1999). Observations after varimax Rotation D1 component explained 69.7% and D2 component explained 14.35%. The item that affects the positive effect on D1 is A-Ashy, F-Celery, and F-Burnt. The rate range is 0.842 to 0.865. The yellowness and F-Tobacco had a less positive effect. However, the high negative effect factor group was AF-Green, AF-Seaweed, and F-Parsley. In D2, AF-Bitter and F-Brown are highly positive by 0.861 to 0.898. The most negative effect was F-Spinach of −0.984 while A-Spinach's score being the least, −0.857.

Fig. 2 indicates bi-plot after varimax rotation. We can divide two groups by 27 points of dissimilarity. The first group includes FYH and FYL, and the second group has GYL, GYH, and JTH. The first group related to green, parsley, and seaweed, while second group related to bitter, brown, tobacco, ashy, and yellowness. As assumed before, the first group (FYH and FYL) had low yellowness, A-Ashy, A-Tobacco, and

F-Tobacco whereas it had high A and F-Green, F-Parsley, and F-Seaweed. However, the second group was reversed. The second group (GYL and GYH) had medium scores of F-Brown, bitter and AF-Bitter while sub-group (JTH) was higher.



JTH: The product on sale in Jo Tae-Hyun Tea Co.
FYH: Fermented Yacon Tea Enhancing Flavor in High Temperature.
FYL: Fermented Yacon Tea Enhancing Flavor in Low Temperature.
GYL: Green Yacon Tea Enhancing Flavor in Low Temperature.
GYH: Green Yacon Tea Enhancing Flavor in High Temperature.

Fig. 2. Dendrogram of 5 yacon leaf tea processes based on PCA score in 17 test sensory attributes.

Acknowlegement

This research was supported by 2012 Sunchon National University Academic Research Grant.

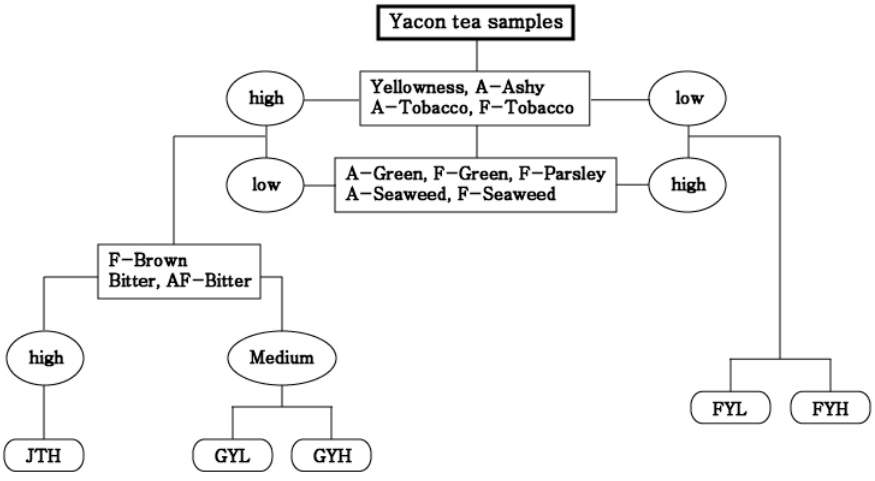
References

Aybar, M.J, A.N. Anchez iera, A. Rau and S.S. Sanchez. 2001. Ypoglycemic effect of the water extract of *Smallantus sonchifolius* (Yacon) leaves in normal and diabetic rats. J. Ethnopharmacol. 74(2):125-32.

Fernández, E.C, I. Viehmannová, J. Lachman and L. Milella. 2006. Yacon [*Smallanthus sonchifolius* (Poeppig & Endlicher) H. Robinson]: a new crop in the Central Europe. Plant Soilenviron. 52(12):564-570.

Genta, S., W. Cabrera, N. Habib, J. Pons, I.M. ICarillo, A. Grau and S. Sanchez. 2009. Yacon syrup: beneficial effects on obesity and insulin resistance in humans. Clin Nutr. 28(2):182-187.

Geyer, M., I. Manrique, L. Degen and C. Beglinger. 2008. Effect of yacon (*Smallanthus sonchifolius*) on colonic transit time in healthy volunteers. Digestion 78(1):30-33.



JTH: The product on sale in Jo Tae-Hyun Tea Co.
FYH: Fermented Yacon Tea Enhancing Flavor in High Temperature
FYL: Fermented Yacon Tea Enhancing Flavor in Low Temperature
GYL: Green Yacon Tea Enhancing Flavor in Low Temperature
GYH: Green Yacon Tea Enhancing Flavor in High Temperature

Fig. 3. Flow chart of how sensory and processing attributes interact, affecting aroma flavors of 5 different yacon leaf tea.

Kim, I.S., J. Lee, J.S. Lee, D.Y. Shin, M.J. Kim and M.K. Lee. 2010. Effect of fermented yacon (*Smallanthus sonchifolius*) leaf tea on blood glucose levels and glucose metabolism in high-fat diet and streptozotocin-induced type 2 diabetic mice. The Korean Journal of Nutrition 43(4):333-341.

Lee, J. and D.H. Chambers. 2010. Descriptive analysis and U.S. consumer acceptability of 6 green tea samples from China, Japan, and Korea. J. Food Sci. 75(2):141-147.

Lee, J., D.H. Chambers and E.T. Chambers. 2014. A comparison of the flavor of green teas from around the world. J. Sci. Food Agric. 94(7):1315-1324.

Lee, J. and D.H. Chambers. 2007. A lexicon for flavor descriptive analysis of green tea. J. Sens Stud. 22(3):256-272.

Obanda, M., P.O. Owuor and R. Mang'oka. 2001. Changes in the chemical and sensory quality parameters of black tea due to variations of fermentation time and temperature. Food Chemistry 75(4):395-404.

Padilha, V. M., P.M. Rolim, S.M. Salgado., A.V.S. Livera and M.G.D. Oliveira. 2009. Avaliação do tempo de secagem e da atividade de óxido-redutases de yacon (*Smallanthus sonchifolius*) sob tratamento químico. Ciência Rural. 39:2178-2184.

Scheid, M.M., P.S. Genaro, Y.M. Moreno and G.M. Pastore. 2014. Freeze-dried powdered yacon: effects of FOS on serum glucose, lipids and intestinal transit in the elderly. Eur. J. Nutr. 53(7):1457-1464.

Shin, D.Y. and I.S. Nou. 1999. Varietal classification by multivariate analysis on quantitative traits in pecan. Plant Resour. 2(2):75-80.

Valentova, K., F. Sersen and J. Ulrichova. 2005. Radical scavenging and anti-lipoperoxidative activities of *Smallanthus sonchifolius* leaf extracts. J. Agric. Food Chem. 53(14):5577-5582.

Wang, L.F., D.M. Kim and C.Y. Lee. 2000. Effects of heat processing and storage on flavanols and sensory qualities of green tea beverage. J. Agric. Food Chem. 48(9):4227-4232.

(Received 28 August 2015 ; Revised 27 October 2015 ; Accepted 7 December 2015)