Chemical Components and Taste of Green Tea

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It has been said that green tea contains various kinds of chemical substances contributing to the taste, such as bitterness and astringency of catechin (tannin), bitterness of caffeine, sweetness of sugars, and sweet and brothy taste of amino acids, and that a good harmony of bitterness and astringency of tannin with brothy and sweet taste of amino acids like teanine might be required for the good taste of green tea.

Based on recent studies such as statistical analysis of taste evaluation by sensory test as related to chemical components of green tea infusion[1], relation between intensities of taste elements and palatability[2], and chemical components contributing to the intensity of of each taste element[3], it has been made clear that, although the basic component representing green tea is catechin, a good taste is attributable to an appropriate concentration of tea infusion and a good harmony of taste of each component including amino acids.

Components of tea infusion and its taste

Two groups of materials were used for chemical analysis and sensory taste evaluation. Group A consisted of 28 samples from high, middle, and low grade domestic Sen-cha*, and Group B consisted of 20 samples of domestic and foreign products. Results are given in Tables 1 and 2. Correlation coefficients between taste scores and contents of each component are also shown in Table 3.

In case of Group A, young shoots harvested by the first plucking gave better taste than matured shoots, showing a high correlation of amino acids and caffeine that are rich in young shoots to the better taste. Although catechin also showed a positive correlation to the taste, free reducing sugars contained in a large amount in matured and coarser shoots gave a negative correlation to the taste.

With Group B of samples, no clear correlation was observed between taste scores and amino acids content as well as catechin content, because foreign products with high catechin content were scored as low as domestic low-grade Sen-cha and Ban-cha that have low content of catechin.

Thus, it was recognized that the relation between chemical components and taste varied with different samples. However, it can be said that a very high content of catechin causes a hard taste, and when there is no considerable difference in catechin content, the higher the content of amino acid the better is the taste.

Multiple-regression analysis made by combining A- and B-groups gave regression coefficients of 0.632, 0.824 and 0.889 for the case only linear term was used, the case squared term was added, and the case when the cross-product term of component contents was included, respectively. That the higher coefficient was obtained by including squared

* Shen-cha : A common green tea made of young tender shoots.
Bancha : A coarse green tea, specially made from the coarser shoots and well re-fired.
Gyokuro : The finest green tea made of the shoots grown under shade.

Table 1. Chemical analysis and sensory evaluation of taste of Sen-cha infusion (A-group of samples)

Grade		Total catechin	Total amino acid	Caffeine	Reducing sugar	Score of taste
		%	%	%	%	
High	1	7.16	3.03	2.33	0.80	18.0
	2	6.54	2.69	2.30	0.89	17.5
	3	6.52	2.92	1.93	0.74	15.5
	4	6.06	2.72	2.32	0.83	17.0
	5	6.58	2.13	2.03	0.86	16.0
	6	6.07	2.77	2.40	0.71	16.5
	7	6.55	2.23	2.10	0.92	15.5
	8	6.81	1.66	1.68	1.18	15.0
	9	7.16	1.91	1.93	0.85	15.0
Middle	1	6.80	1.49	1.86	1.11	13.5
	2	7.33	1.47	2.04	1.78	13.0
	3	5.42	0.80	1.57	1.58	13.0
	4	5.82	1.77	1.97	1.05	14.0
	5	6.86	1.85	1.59	1.05	12.0
	6	6.48	1.22	1.80	0.98	12.5
	7	5.51	1.33	1.57	1.33	13.0
	8	5.28	1.03	1.36	1.58	12.0
	9	6.08	0.87	1.58	1.80	12.5
	10	5.94	0.96	1.55	1.49	11.0
Low	1	6.25	0.90	1.52	1.17	12.0
	2	5.72	0.67	1.48	1.51	12.5
	3	6.53	1.01	1.71	1.07	9.0
	4	5.78	0.60	1.46	1.63	10.0
	5	4.97	0.78	1.51	1.52	7.0
	6	4.81	0.67	1.15	1.58	10.0
	7	5.85	0.66	1.54	1.58	9.0
	8	5.88	0.67	1.54	1.20	8.0
	9	5.68	0.63	1.77	1.32	7.0

Table 2. Chemical analysis and sensory evaluation of tasts of green tea infusion (B-group of samples)

Kind of green tea		Total catechin	Total amino acid	Caffeine	Reducing sugar	Score of taste
		%	%	%	%	
Formosa	1	5.51	0.73	1.35	1.50	6.0
	2	7.66	1.45	1.97	0.65	14.0
	3	6.45	0.62	1.59	1.47	13.0
	4	10.80	1.27	2.25	0.45	10.0
Indonesia		13.21	1.47	2.44	0.62	8.0
India		12.56	1.23	2.52	0.65	6.0
Brazil		13.14	2.49	2.72	0.60	9.0
Sri Lanka		12.70	1.64	2.34	0.97	5.0
Sen-cha						
High	1	8.11	3.00	1.57	0.83	15.0
	2	7.46	1.89	2.02	1.48	11.0
Middle	1	9.56	1.17	1.91	0.86	12.0
	2	6.33	1.13	1.98	1.34	8.0
Low	1	5.93	0.66	1.79	1.19	6.0
	2	7.21	0.82	1.65	1.56	11.5
Gyokuro	1	7.21	2.94	2.71	0.64	12.0
	2	5.86	4.03	2.31	0.58	17.0
Ban-cha	1	5.00	0.71	1.20	0.71	7.0
	2	3.90	2.34	1.16	1.10	5.0

Table 3. Correlation coefficients between taste score and content of chemical components

	Sample group	
	A	B
Total catechin	0.640**	−0.261
Total amino acid	0.880**	0.276
Caffeine	0.768**	−0.028
Reducing sugar	−0.632**	−0.303

**: $P<0.01$

term indicates a curved line relationship between taste and chemical components.

Intensity of taste-elements and palatability

Taste of green tea infusion is constituted of four taste-elements: bitterness, astringency, brothy taste and sweetness, and a good harmony of intensities of each element, within an intensity pattern specific to green tea, may give a good taste. A study was carried out to know the relation between palatability and intensity of each element, measured by sensory test, using test materials infused under different conditions or with additives for changing intensities[2].

A standard method of infusing tea in the sensory test is to add 180 ml of hot water to 3 g of green tea leaves, leave it still for 5 minutes, and remove the residue. Taking the concentration of the infusion thus obtained as 1, different concentrations ranging from 4/9 to 9/4 were prepared with middle-grade Sen-cha. As given in Fig. 1, concentration of 1 to 2/3 showed the highest palatability, to which the intensity of brothy taste was closely correlated. Both higher and lower intensity of bitterness and astringency lowered the palatability.

Addition of theanine to a middle-grade Sen-cha infusion caused an increased brothy taste and resultant increase of palatability, but a great amount of theanine suppressed bitterness and astringency and lowered palatability (Fig. 2).

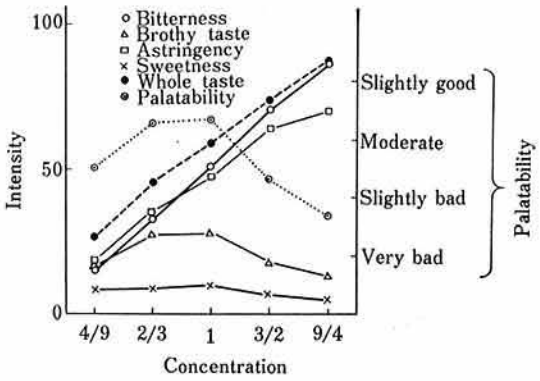

Fig. 1. Relation between palatability and intensities of taste-elements at various concentration of infusion

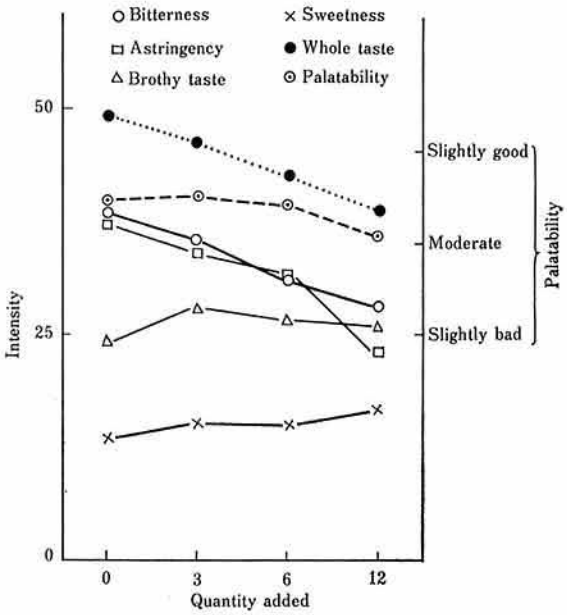

Fig. 2. Effect of addition of theanine on intensity of taste-elements and palatability

Addition of sodium glutamate and sucrose to a middle-grade Sen-cha infusion caused an increased brothy taste and sweetness, but a decrease in bitterness and astringency, Brothy taste of glutamate is slightly different resulting in a lowered palatability (Fig. 3). from that of green tea and an increased brothy taste and sweetness might have given a different taste from that of green tea.

Table 4. Chemical composition of fractions of green tea infusion

Fraction	Soluble matter	Soluble nitrogen	Caffeine	Amino acid	Tannin	Reducing sugar	Soluble protein, pectin
	%	%	%	%	%	%	%
1	4.17	3.74	10.83			3.04	100.00
2	29.82	49.43	55.23	86.00		54.26	
3	30.12	31.45	40.79	19.01	20.96	32.31	
4	18.48	6.00	3.61		30.47	7.31	
5	10.06	2.99	2.52		23.83	3.04	
Recovery	92.65	93.62	112.98	105.01	75.26	99.96	

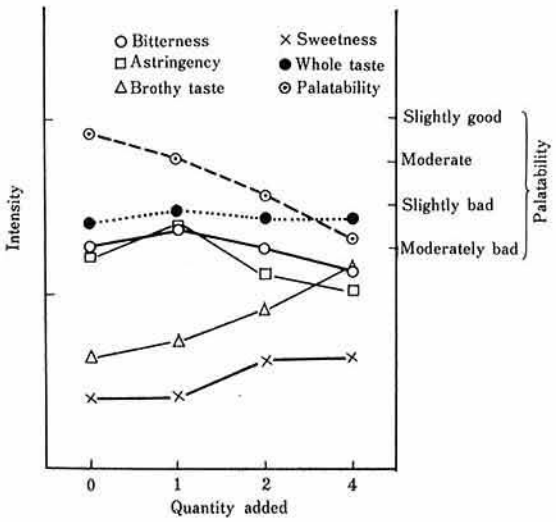

Fig. 3. Effect of addition of mononatrium glutamate and sucrose on intensity of taste-elements and palatability

These results indicate that there exists an appropriate intensity of combined taste as well as of bitterness and astringency, and that within a range not spoiling the taste specific to green tea the higher intensity of brothy taste gives better palatability.

Contribution of chemical components to taste-element intensity

Tea infusion was analyzed by liquid chromatography with Sephadix G-75 as a fixed phase and water as a moving phase, and the effluent was separated into five fractions by measuring ultraviolet ray absorption and color. Chemical analysis of each fraction indicated that major components were separated into each fraction although some of them were contained in two to three fractions. In Table 4, contents of major components in each fraction were expressed in percentage of these components contained in the original tea infusion. Recovery rates of soluble components were higher than 90% in general, with an exception of tannin which showed somewhat low rate of recovery.

With these five fractions, intensities of taste-elements were determined and expressed in terms of percentages of those of the original infusion. As shown in Table 5, bitterness and astringency are limited to the fraction containing tannin, principally catechin. Removal of tannin by polyvinylpyrolidone treatment resulted in a elimination of bitterness and astringency by more than 75%. This indicates that tannin is responsible for more than 75% of these tastes.

Table 5. Intensity of taste-element in each fraction

Fraction	Bitterness	Astringency	Brothy taste	Sweetness
1	0.54%	1.09%	23.66%	23.06%
2	3.26	5.94	48.23	46.16
3	20.16	22.90	20.72	20.88
4	36.78	35.68	4.43	4.39
5	39.23	34.36	2.94	5.48

Similarly, about 70% of brothy taste and sweetness are found in the fraction containing amino acids and reducing sugars. Removal of amino acids by ion-exchange resin caused a elimination of brothy taste by 65% and

of sweetness by 20–50% indicating that the amino-acids are responsible for about 70% of the brothy taste, whereas sweetness depends more on sugars[3].

Conclusion

It was made clear that the taste of green tea depends on the harmony of taste-elements, i.e., relative intensity of each element.

However, it is well-known that mild brothy taste has been required for Gyokuro and high-grade Sen-cha whereas refreshing stimulative taste has been required for usual Sen-cha. For the former better taste can be obtained by infusion for a long time at a relatively low temperature with less amount of hot water, whereas quick infusion at high temperature gives better taste for the latter. An optimum concentration of infusion with highest palatability is higher with higher-grade Sen-cha, with higher content of catechin and amino acids of the infusion. Thus, the best combination of relative intensity of taste-elements may differs with kinds of tea.

Furthermore, flavor is not neglected for better taste. For the analysis of complicated and extremely delicate problems of taste, not only chemical studies but also physiological and psycological approach including a dietary habit will be needed.

References

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