Color of Tea Infusion

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In evaluating the quality of tea, the color of tea infusion is one of the important items besides the aroma and taste. It performs a service of inciting an appetite by directly appealing to man's eyesight prior to drinking, and it is a factor by which the quality of tea can be judged at first. That is, by the color of tea infusion it is possible to judge the raw material and the handling thereof, quality of processing technique, storage method and the degree in quality change.

In such a way the manufacturing process largely influences the quality of tea and the experiment and research on color of tea infusion have mainly been directed to the improvement of manufacturing technique in order to ensure the improvement of quality ultimately.

Accordingly, the research carried out heretofore on the color of liquor has been based only on the manufacturing conditions, the differences of the condition in storage and exudation. And as of now there has been no research on chemical constituents which manifest the color of liquor.

Chemical constituents participating in manifestation of color of tea infusion

Tea infusion is characterized by various kinds of pigments. It is assumed that practically no chlorophyl, carotin and xanthophyl are drawn out from tea infusion by the method of preparing tea as practiced at present.

The color of green tea infusion is yellow, so as the constituents which provide a yellowish color by hot water, these flavonols have been known and there are also the flavones as clarified by a series of research carried out by the writer.

Besides, it has been estimated that there exist low grade oxidation products of catechins, amino-carbonyl reaction products and caramelized products of sugar. The reddish pigments which manifest the color of black tea infusion have been called theaflavins and thearubigins, and the structures of some theaflavins have been confirmed by the outstanding works of Takino et al. Those are the enzymic oxidation products of tea catechins.

1) Oxidation products of catechins

About 10 to 15 per cent of catechins are contained in the leaf and the Assam varieties contain more. As the catechins themselves are colorless, they have no direct influence on the color of liquor. However, the catechins are very unstable and become oxidized by exposing only to atmosphere and become gradually colored. And heat accelerates the change.

Oxidation is also occurred by action of the enzyme. The manufacturing of black tea is one of a very few examples of utilizing enzymatic oxidation of catechin. The catechins produce the coloring products by oxidation and polymerization under oxidizing action of enzyme in the tea leaf during the manufacturing of black tea.

The pigments, theaflavins characterized by a bright reddish orange color among the ingredients causing the color of black tea infusion, have mainly been clarified as to the structures by detailed research conducted by Takino et al. That is, they are enzymic oxidation products of four kinds of major catechins in tea leaf, each having benzotropolone nucleus and the beautiful red color is based on this structure. (Fig. 1)

a positive correlation is observed in the black content of the liquor by transmittance and in the thick liquor thearubigin is necessary but in the rather dark color of the liquor due to over-fermentation the content ratio is higher.

From these facts as the content of thearubigins provides the depth and thickness to the color of tea infusion, it is necessary inside certain limits but it has been clarified that on

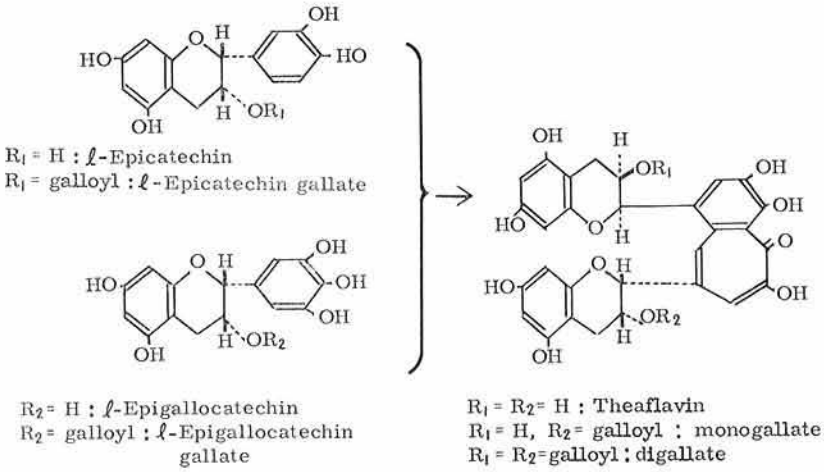

Fig. 1. Chemical composition of Theaflavin

Another kind of pigments, thearubigins as reddish brown—darkish brown, which provides a depth and thickness of color to liquor of black tea, is complicated in its composition and as to mechanism of formation and chemical structure there are many unknown points.

The thearubigins are assumed to be as highly oxidized and polymerized products than catechins but the existence of the combination with ingredients such as caffeine, anthocyans amino acids and proteins has been estimated.

As to the correlation between the content of theaflavins and thearubigins and the color of black tea infusion, the research findings of the writer et al. recognized that the higher the theaflavin content the better the color of the liquor, and a positive correlation has been recognized in the color evaluation marks of the liquor and in the thearubigin content

the contrary, too much of it damages the color of tea.

In the process of green tea manufacturing, the tea leaves are steamed or pan-fired (kamairi) at the very start of the manufacturing; thus, the enzyme is inactivated. Accordingly, it differs from the case of black tea in that enzymic oxidation of catechins is observed.

However, because of the fact that rolling and heat treatment goes on for more than two hours in the manufacturing of greet tea, it has been assumed that the oxidation of catechins which is very unstable has taken place to some extent.

Due to the fact that optical extinctions near 460 mμ of color of green tea infusion declines about 20 to 30 per cent after the polyclar-AT treatment, that portion can be

assumed as the color tone due to the oxidized coloring matter of catechins.

However, owing to the fact that the color tones of those catechins coloring matters are accompanied by a reddish color rather than yellowish tone ,a large amount of oxidation products is found to be unsuitable for the color of green tea infusion in general with the exception of 'Kamairicha' and 'Hojicha' which are strong in tint of red in liquor color due to high temperature treatment.

2) Flavone and flavonol pigments

Over 20 kinds of yellow pigments belonging to flavonol have been detected from the tea and chemical structures about 10 kinds have been identified. (Table 1)

Due to the fact that the flavonol pigments dissolve in hot water and manifest a greenish yellow—clear yellowish tint, it is believed that the color of green tea infusion is largely dependent on those flavonol pigments.

Particularly, because it has been assumed that triglycosides are very water soluble so that they can be easily extracted by decoction of black and green tea, they play an important role in contributing to the manifestation of beautiful yellowish tint in green tea and the golden ring phenomenon in black tea.

Besides the pigments belonging to those flavonols, 22 yellow pigments belonging to flavone have been discovered by the writer in the green tea infusion. Those flavone pigments belong to the C-glucopyranosyl-flavones which have been discovered in recent years and it has been suggested that all of them have the same skeletons as apigenin. They are strongly water soluble and it has been assumed very important as an ingredient manifesting the color in green tea infusion. And two kinds of pigment which are the largest in content and very strongly water soluble have been isolated for first time from natural sources and they have been named Theiferin A and B respectively. Both have the structure of 6, 8-di-C-glucopyranosyl Apigenin and are interconvertible to each other.

The flavone pigments which have been identified are shown in Fig. 2.

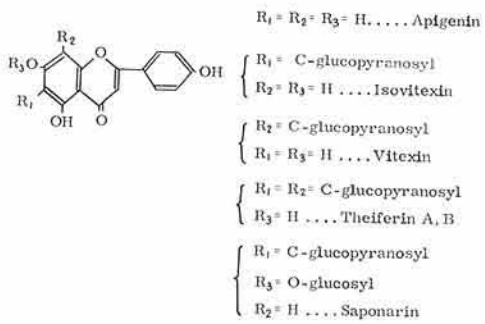

Fig. 2. Flavone pigments in tea leaf

Upon computing the degree of contribution by total flavone and flavonol content on green tea liquor by optical extinctions at 460 mμ indicates about 24 per cent, although there are some fluctuation by the materials used in the experiments and it was also found that about one-half was due to glucopyranosyl flavones. Those flavone and flavonol pigments are not decomposed at all by the green tea manufacturing process. So in order to ensure a product of good liquor it is necessary to

Table 1. Flavonol pigments in tea leaf

Aglycone			
Sugar	Kaemferol (K)	Quercetin (Q)	Myricetin (M)
Mono	Astragalin (K-3G)	Quercitrin (Q-3R)	Myricitrin (M-3R)
		Isoquercitrin (Q-3G)	M-3G, M-Gal
Di-	K-3RG	Rutin (Q-3RG)	M-3RG
Tri-	Kaempfetrin (K-3RGG)	Quertrin (Q-3RGG)	
	K-3GGG	Q-3GGG	

R = rhamnose G = glucose Gal = galactose

select a variety which has a higher content of flavones and flavonols.

3) Other ingredients

The liquor of 'Gyokuro' and high grade 'Sencha' is said to be better if it is of light yellowish color tinted by a green color. As for the reason for this green color it has been assumed heretofore as due to flavonol pigments but chlorophyl and its decomposed products have been extracted from the tea infusion.

As the chlorophyl is not water soluble it may be decocted in the form of microscopic colloid or as oily substance. It has also been found that there exists a considerable amount of green pigments seemed as decomposed products of chlorohpyl.

In the optical extinctions at 660 mμ, 'Gyokuro' and high grade 'Sencha' with its liquor tinted by greenish color, the value is higher, and the the value is lower for low grade 'Sencha' and 'Bancha' with their liquor not tinted by greenish color. From these facts it has been assumed that chlorophyl and its decomposed products are largely responsible for the greenish color of high grade tea liquor.

As for other ingredients, there are supposed to be cloring substances by non-enzymic browning that generally occurs in food. It has been assumed that as thoroughout the whole manufacturing process of green tea the heat is applied practically continuously, browning is produced by amino-carbonyl reaction and decomposition of sugar and there is also the possibility of browning by caramelizing of sugar, decomposition of sugar by organic acid, ascorbic acid and amino acid. And the reaction of those ingredients with catechins can also be assumed.

In fact, in green tea infusion the presence of brown color material has been derived from nonflavonid substances which have been deemed as caused by various reactions thereof. Those brown color products are of brownish color under dense condition but in thin aqueous solution it manifests a dull yellowish color.

It has been assumed that in the main constituent of yellowish color of liquor of ordinary 'Sencha', the proportion of pigment by those ingredients is higher and the higher the grade of 'Sencha' the liquor is the same proportion and manifests a beautiful clear yellowish tint caused by flavones and flanovols.