THE CHEMISTRY OF TEA.

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It was recently announced that the Board of Control of the Tea Research Institute of Ceylon proposed to set aside a sum not exceeding Rs. 5,000 which they are prepared to contribute to a scheme for a special investigation of the chemistry of tea.

This scheme is dependent on the active co-operation and support of other Institutes carrying out research on tea problems, and it is hoped that it will be possible for the investigation to be entrusted to an eminent chemist such as a University Professor of Chemistry who has the facilities for such work to be carried out in his own laboratories under personal supervision.

Since it may not be apparent to all interested in the Tea Research Institute why such a scheme is necessary, it is proposed to outline our present knowledge of the chemistry of tea, and to explain what we hope to gain from the expenditure.

The Chemistry of tea as a subject does not lend itself readily to popular treatment and it is to be hoped that non-technical readers will not abandon their efforts to read through this article as soon as they come upon long names, and that the few technical readers will realise the limitations imposed and refrain from using the writer's own words as evidence against him should he ever publish papers under the same caption in technical journals. The main object of this journal is to keep the Ceylon Tea Industry in touch with the activities of the Institute and it is in that spirit that the article is written.

Generally, there is very little misconception, popular or otherwise, about the principal ingredient of the brew prepared from tea leaves. Almost every tea drinker is aware that tea contains a substance termed "tannin." The more timid members of this class have vague notions that it causes hob-nail liver or a leather stomach, while aggressive reformers who are always prepared to fear the worst about the effects of almost any food, except the most unpalatable, speak glibly of supposed ill-effects which arise from partaking of a liquid which in their view should be prohibited outside tanneries. The basis of these assumptions, for they are no more than assumptions, is the

ill-informed association of tea tannin with substances used for the production of leather. Terms of a general nature such as this word "Tannin" are very misleading at times, and even to people with specialised knowledge a loose term is apt to be very confusing unless they have personal experience of the particular group of substances which the term indicates. Thus, many people ranging from ill-informed neurotics engrossed in their digestive troubles to scientific and technical persons who would have been better served by a more accurate name, have fallen into the snare laid by the use of the unfortunate word "Tannin" probably derived from a Celtic word meaning "Oak" and later adopted to describe the substances (cf. tan liquor) and occupations (cf. tanner) concerned with leather making.

There are wide differences between different tannins in the same way as there are very marked differences in the properties of many substances included in the Alkaloid Group. A medical man would never confuse Strychinine with Morphine or Quinine although they are all members of the Alkaloid Group and have common chemical reactions which justify their being grouped together in a classification, yet the "Tannic Acid" of the Pharmocopoeia is not always clearly distinguished from tea tannin which is very different in chemical composition and properties, although both precipitate common reagents and have other common chemical reactions which justify their inclusion in the "Tannin" Group. If some other word had been used for the "Tannin Group" in the same way as "Alkaloid" has been used for the group which includes Quinine and Morphine, the ridiculous idea of tea turning the stomach wall into leather would probably never have been conceived.

Tannins as a class of substances have received very scanty attention compared to other well-known groups such as Alkaloids, Carbohydrates, etc., while the members of this group which occur in tea have not even had their proportionate share of attention as individuals of a very large class. Most of the work done on tannins has been devoted to the Gallo-tannins which are actually used in leather making; thus Nierenstein in a book of three hundred pages on the natural organic tannins devotes barely one page to Tea Tannin and says "The Chemistry of the Tannins is full of contradictions but in no special case are the contradictions so pronounced as in the case of the Tannin present in *Thea chinensis*, Sims., *Thea sinensis*, L., *Camellia Thea*, Lk., *Camellia theifera*, Griff. and *Thea Assamica*, Mast." To some extent the lack of progress with the chemistry of tea has been due to the lack of workers in this particular field which for some reason has not attracted attention from research workers on organic chemistry. In addition to this relative lack of

attention the somewhat complex and difficult nature of the tannins has also tended to impede progress, so we must appreciate the efforts of those workers who have given us the information we have at present and remember that future work will become less difficult as a result of the information they have made available. It is quite conceivable that once attention has been drawn to the relatively unexplored realms of the chemistry of tannins, as a result of work subsidised by the Tea Industry, a number of Academic Chemists may be tempted from the well-trodden paths in the realms of Plant Pigments, Alkaloids, Carbohydrates, etc. Although Industrial and Commercial Chemists are apt to gibe at purely academic work, we must all admit that it has provided the foundation and the framework of our knowledge. Nothing could be more helpful than general academic interest in the Tannins as a class.

We cannot consider in detail the whole of our present information or mention the names of all those whose have contributed to it. To Shaw, late of the South Indian Research Station, must, however, be given credit for attempting to distinguish the Tannins of tea by introducing the word "Theotannin," thus taking the first step forward enabling a distinction to be drawn between the substance of the tea leaf and others such as tannic acid of the pharmocopœia which is used for the treatment of diarrhoea, and as a coagulent in cases of burns, or from a variety of other substances used for tanning and for the manufacture of ink.

Shaw carried out a good deal of work on the separation and purification of the tannin substances of the tea leaf, also, with the aid of Jones, on the analytical estimation of Tannins as a group of substances occurring in tea. These researches extended the earlier work of Deuss and others.

Until quite recently the idea of Theotannin as a group of substances of the tannin class does not appear to have been actively entertained. Vague references have been made from time to time to inherent possibilities but very little active work on this aspect was undertaken until quite recently. The work of Russel in an English University Laboratory who made a study of the tannin in Hemlock, gave impetus to an investigation of the tannin substances of Formosan tea leaf, with the result that an amorphous tannin has been synthesised by Oshima who claims that his synthetic product is identical in all its properties with the amorphous tannin isolated from Formosan tea leaf. Oshima also states that this synthetic tannins closely resembles the tannin substances isolated by others including Deuss, Shaw and Tsujimura, but differs in purity.

There is an urgent necessity, therefore, for a repetition of this work to ascertain whether the conclusions apply equally to Ceylon tea leaf.

Shaw claimed to have separated some crystalline tannin from his preparation which indicates the presence of at least one other tannin in South Indian tea leaf, while Tsujimura isolated a substance of the tannin class which she claimed to be the gallic ester of a catechin. Previously she had investigated this catechin and called it tea catechin. In 1936 Deijs and Dijkman of the Java Tea Research Station published work confirming Tsujimura's findings and thus indicating that one tannin in Java leaf corresponds to a tannin in Japanese leaf, alhough Oshima was unable to detect the presence of this particular substance in Formosan leaf. Shaw was also unable to confirm Tsujimura's findings, while at St. Coombs we repeated the work of Deijs and Dijkman during 1937 and came to a conclusion in agreement with Oshima and Shaw.

Sufficient has been said to indicate differences in the chemical composition of the tannin substances occurring in the leaf of different countries. It is not unreasonable to suppose that there will be differences within Ceylon according to elevation, district and possibly season. The mixed jats of Ceylon may also complicate our problem. Besides the true tannins characterised by their ability to precipitate gelatin, there are other rather simpler substances present in tea leaf which belong to the same class of organic compounds as tannins, but differ in that they do not precipitate gelatin; these substances are called catechins.

There are several different catechins which may occur in tea. The catechin mentioned above as Tea Catechin and isolated by Tsujimura has been the subject of a long controversy. Oshima has isolated considerable quantities of a catechin called Gallo-catechin from Formosan tea leaf which substance is very closely related to the amorphous tannin.

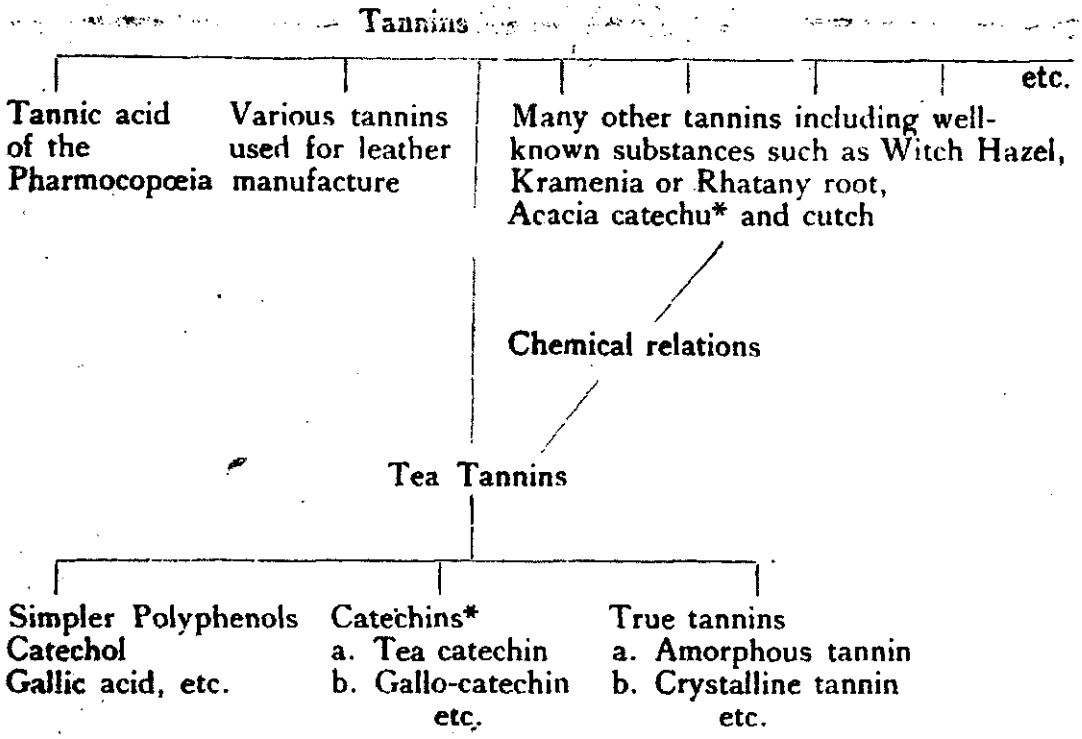
At St. Coombs we have isolated Gallo-catechin from Ceylon tea leaf by following the method of Oshima.

Of the class of compounds which we have in general termed Tannins we need only consider one other group which we will refer to as simple Polyphenols. In case of any possible confusion to the non-technical reader we will recapitulate to the extent of setting out the classification which we have adopted for the purposes of this article. To the substances of the tannin group which occur in tea we have given the general name Tea Tannins or (after Shaw)

Theotannins. Three sub-groups of tea tannins were then described:

1. True tannins.
2. Catechins.
3. Simpler Polyphenols.

In order to give a picture of Tea Tannins in relation to other tannins with which they are confused we will draw up a family tree as follows:—



Further description of the tannin substances in tea leaf will only serve to confuse, so the more practical aspect of the proposed investigations will now be considered. During fermentation which starts immediately the juices of the tea leaf are exposed to air, the tannin substances are changed to coloured compounds which are soluble in hot water and contribute the major part of tea liquors. The practical man knows quite well that different kinds of leaf, differences in the manner of expressing the juices of the leaf, and differences in the manner of fermentation, all influence the production of coloured substances. As well as the colouring matter which

* One of the Acacia catechus is probably identical with a catechu occurring in Tea. Acacia catechu which is separated during the manufacture of Cutch is used for chewing with betel, etc.

is soluble in hot water and dissolves into the liquors, there is insoluble pigment produced during fermentation which remains in the infused leaf. From the importance attached to the colour of these insoluble pigments by tea tasters we infer a close association between the production of a desirable colour in the infused leaf and desirable properties in the liquors.

These changes in the tannin substances are brought about by enzymes which are themselves non-living organic compounds. During the life of the leaf they take part in the living processes of the cells and in death they assist in processes of decay. Enzymes may be differentiated by their reactions, and in tea manufacture we are mainly concerned with those causing the cells to become permeable during the process of withering and the comparatively limited number causing the changes in the tannins during fermentation.

The position is therefore, in short, as follows:—

The tannins, catechins and other polyphenols, as a result of enzymic action, give rise to both soluble and insoluble coloured pigments, which are responsible for the colour of liquors and infusions. Besides colour in liquor these substances arising from the tannins of the tea leaf are mainly responsible for strength and pungency. We therefore wish to know the exact nature of each of the tannin substances present in green leaf and also their relative amounts under different conditions of elevation, season, jât, etc. It should then be possible to elucidate the problem of fermentation and the part played by each of these substances in the production of colour, strength, pungency, and also to find the connection between good liquors and good infusions. It is quite conceivable that the optimum conditions of time and temperature vary for each individual substance, in which case those responsible for the most desirable characters would receive the closest attention. A knowledge of the causes of dullish brown or persistently greenish infusions, and of the causes of greenish bitterness in liquors, would also be of immense practical value.

We have by no means wandered into the realms of idle speculation for at St. Coombs we have already studied the effect of tea enzymes upon certain individual tannin substances, and have succeeded in isolating products of the reaction. Russian workers have studied the same problems from a slightly different angle by adding various polyphenols to fermenting leaf. Their results are very interesting indeed so a table from a paper of Kursanov is reproduced.

Added Polyphenol	Intensity of Colouring of Infusion* % Standard.			
	Test 1	Test 2	Test 3	Tint of Infusion*
Control (water)	31	28	27	Reddish brown (Normal)
With guaiacol	41	29	40	Red mixed with brown
,, pyrogallol	46	48	41	Dark brown
,, gallic acid	50	55	44	Dark brown with grey tint
,, phloroglucine	19	21	16	Yellowish mixed with green

* The word infusion in the translation from the Russian refers to the soluble pigment, *i.e.*, the liquor.

Comparing the intensity and nature of the colour produced when phloroglucine was added, with that of the control when water alone was added, it is of interest to note that production of colour was actually inhibited and that the liquor assumed a greenish tint. It is not at all improbable that reactions of this nature may take place in actual practice at certain periods of the year. The writer has come across cases where all efforts to eradicate greenness of liquor have failed, and where such difficulties have disappeared apparently of their own accord when the type of leaf changed.

A good deal of information is available about the enzymes of tea as a result of work carried out in almost all tea producing countries. It is therefore possible to end this section dealing with Tea Tannins on an optimistic note, for it would appear that the proposed scheme for research on the chemistry of tea, which should not meet with any serious difficulties now that money has actually been provided, will furnish information that will enable rapid progress to be made in practical tea manufacture.