AROMA COMPLEX — WITH SPECIAL REFERENCE TO TEA

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The ' aroma complex ' of foods and beverages is a subject on which intensive scientific research is now being carried out in many laboratories throughout the world. The aroma complex is mainly due to the presence of volatile compounds (*ie* compounds which vapourize easily) in the original material and is perceived by man by the sense of smell. Although the olfactory faculty is the most primitive of the three senses in man, it responds remarkably to thousands of volatile compounds which may be present in the atmosphere.

As a result of modern methods for the chemical identification of volatile compounds, it is now possible to obtain a better understanding of the chemical composition of aroma complexes. The two main methods used for the isolation of volatile compounds which are responsible for aroma complexes are steam distillation and solvent extraction. Steam distillation is a very rapid method of isolating volatile compounds and it eliminates the risk of contaminating the aroma complex with solvents and their impurities. However, certain problems arise in both isolation methods, namely, the instability of the aroma complex, the formation of artefacts and the very small amounts of volatile compounds present. (On an average, black tea contains only 0.017% oil when compared with the original extract.) The isolated volatile compounds are concentrated, purified and then identified by sophisticated methods such as spectrophotometry and chromatography, and also by the well-known classical methods such as melting point determinations, elemental analysis and colour reactions.

The principal separation techniques used are gas chromatography and thin-layer chromatography. These are methods which enable the separation and identification of volatile mixtures in very small quantities. Using gas chromatographic techniques, research chemists have identified eighty three volatile compounds in tea, while it has been shown that cocoa and coffee contain forty and eighty five such compounds respectively. The picture in each case is not complete, as many more compounds are yet to be identified. I would like to mention, however, that although these methods have been in use for about fifteen years, the first natural flavour of a food has yet to be fully characterized. These instruments have shown the complexity of the study of aromas, hence the word aroma complex. Success in studies on the aroma complex of foods and beverages will depend on the identification of all the volatile compounds and an adequate knowledge of the relative concentrations of these compounds. Trace amounts of them may play an important role in determining the identity of the aroma complex.

The main groups of volatile compounds present in foods and beverages are the aldehydes, ketones esters, alcohols, acids and terpenes. The last group includes many hydrocarbons. These compounds are of great importance in flavour chemistry and in some cases just one such compound is responsible for the characteristic flavour of a particular food. For example ; in grape fruits it is a ketone, in pears and apples they are esters and in mushrooms it is an alcohol. I am not trying to imply that in tea, one compound is responsible for the aroma complex. We believe that a group of compounds is responsible for this aroma complex.

In the past, studies on the chemistry of tea have been confined mainly to the polyphenols, a group of water-soluble compounds, some of which are responsible for quality in tea, and very little attention has been paid to the other constituents of

tea especially the fat-soluble compounds which include many volatile compounds. This situation has changed very rapidly in the last few years and intensive research on the volatiles of tea is being now carried out especially in Japan, Russia, the United States of America and Ceylon. I shall outline some of these important findings.

In 1957 and 1958, Russian workers at the Institute of Biochemistry, Moscow, have shown the presence of aromatic aldehydes in tea, such as vanillin, and these workers are of the view that these compounds are partly responsible for the aroma complex of tea. These workers have subsequently isolated many complex esters from black tea. These include acetates, butyrates and valerates in the Russian teas, while the Ceylon teas contained in addition to the above, propionic acid esters. Another Russian worker, Gogiya, in 1965, studied the chemical changes of esters during the manufacture of tea. He found that esterification was intense during fermentation when salicylates and caproates were formed. It is possible that these esters are responsible for the aromatic odours emanating from factories. During the firing of tea most of these compounds were unaltered, while during storage new compounds appeared. Some of these compounds may be responsible for off-flavour during storage, and others for the development of flavour during storage.

Excellent work has been done by a Japanese group led by Professor Yamanishi of the University of Tokyo. These workers have identified more than forty volatile compounds ; some notable examples of these are jasmone, a ketone (odour of jasmine flowers) ; linalool, a terpene alcohol (odour of lavender) and geraniol, another terpene alcohol (odour of roses). Using thin layer techniques, the occurrence of some of these compounds have been confirmed in our laboratories.

An extensive study of the volatile compounds of tea has been made by a group of American workers in New Jersey, this year. Using gas chromatographic studies, they have shown the occurrence of eighty three volatile compounds in tea. These workers have isolated an oil from tea (which has an odour reminiscent of tea, but is not properly balanced). They found substantial quantitative differences in teas of different origin and have also observed that the high-boiling (above 100°C) volatile compounds seem to play an important role in the flavour of tea. Using the solvent extraction method, followed by thin layer chromatography, we have shown in our laboratories that even qualitative differences were found in Georgian, Darjeeling and Uva black teas. Further, we have made a study of the low-boiling (below 100°C) volatiles of black tea and have shown that flavoury teas contained a low concentration of an aldehyde, methylbutraldehyde.

Although the volatile compounds already present in the oil of tea (not to be confused with tea seed oil) are mainly responsible for the aroma complex it has been shown by Russian workers that some volatile compounds are formed by the interaction of other compounds. These workers used different amino acids as the starting material and obtained teas with different aromas. We have made a similar observation as certain aldehydes are formed from the marino acids by their interaction with oxidizing agents. A study of the carotenoids (a group of yellow pigments) of tea was carried out in our laboratories two years ago with the ultimate objective of studying the volatile compounds formed by their oxidation during tea manufacture, as these may contribute to the aroma complex of tea. It is interesting to note that two of these oxidation products α and β ionone have now been identified by American workers. These two compounds in very low concentrations have an odour reminiscent of violets.

I would also like to mention another line of research carried out in our laboratories. We have shown the occurrence of certain antioxidants in tea such as β and γ tocopherols. (Antioxidants prevent the oxidation of other compounds.) The

relative concentrations of these compounds may give sufficient protection to the volatile compounds found in flavoury teas, from the powerful oxidizing activity of the quinones formed during tea manufacture. This could be a method for the development and preservation of tea flavour which otherwise may be destroyed. During this study we discovered the occurrence of vitamin E in black tea, and I only hope that from a medical point of view, this discovery is not going to bring about a population explosion in a country already having a difficult food problem.

The present knowledge of the volatile compounds of tea will undoubtedly be a very useful guide for the flavour chemists of the future. Chemical studies on flavour should be guided by the reports of the tea taster, who makes a descriptive analysis of tea flavour, such as its order of appearance and its intensity, and his assistance is necessary in tea flavour research, although it is sometimes possible that three different tea tasters may give three different reports on the same sample of tea.