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*BY-PRODUCTS OF TEA

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Considering the large extent of land which is under tea, it appears disproportionate that the only economic return is by the export of tea for use as a beverage, and here too it is only black tea which accounts for the total production of about 500 million lb. The other varieties of tea, *eg* instant, green oolong and paochong form only a negligible fraction of our tea exports. These cannot, of course, be regarded as by-products of a black tea industry, and are in the nature of a diversification of output. A start in the production of instant tea was made some years ago, but the factory situated at Agrapatana produces less than 150,000 kg per year, which is far below the projected output of 1 million kg. In this connexion, the consumption of instant tea in the United States alone which was about 10 million kg. in 1965 rose to 19 million kg in 1969, and it would appear that the potential for instant tea is expanding rapidly. With regard to green tea, sporadic attempts at production have been made in the past few years, but as in the case of instant tea, problems of marketing have prevented the uninhibited expansion of this line of product diversification. Oolong tea is semi-fermented tea, whilst paochong tea is slightly fermented tea. Both types are manufactured exclusively in Taiwan, and have a limited, but profitable, market in the United States. Carbonated tea is yet another new form of tea and it is reported that this may be a promising line of diversification.

Considering next what may be regarded as proper by-products, the most obvious source of these in a black tea-producing industry is waste or refuse tea, which accounts for 3 to 4% of the black tea production. The component of tea waste which is best known is caffeine. Tea waste contains 1.5 to 3.5% caffeine, and the commonly-used method of extraction of this alkaloid is by the use of solvents. Chloroform, carbon tetrachloride, trichloroethylene, benzene, alcohols, and various mixtures of these have been used for this purpose, and are the subject of numerous patents. Adsorption and sublimation methods have and are being, tried out, but at the present time, solvent extraction is the method of choice,—the main problem appears to be efficient recovery of the solvent (usually trichloroethylene). Apart from its pharmacological properties, caffeine is also an essential ingredient of carbonated beverages, notably Coca Cola and Pepsi Cola. The market for caffeine from waste tea has, however, been insecure, partly because caffeine also acours in matē leaves, cola nuts and *Paullinia* sp., partly because caffeine is a by product of the decaffeinated coffee industry, but mainly because of competition from synthetic caffeine. The United States and the United Kingdom each import about 150 tons of caffeine, and Japan and some middle-eastern countries import smaller quantities, but these requirements are, for the most part, met by synthetic caffeine. India is, however, planning to step up the production of natural caffeine from tea waste to 100 tons per year from the level, in 1968, of about 11 tons per year. In Ceylon, approval was given in 1968 to two campanies for the manufacture of caffeine locally, and these are reported to have commenced production.

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Another use for waste tea, worked out in Russia, is the extraction of colouring matter for the confectionery industry. Green, yellow and brown pigments, corresponding to the chlorophyll and polyphenolic material, are being extracted and used for this purpose. In addition, waste tea also contains about 5% pectin and 20% cellulose, and work has suggested that they may be by-products which could be exploited. Another possible use for waste tea is as a culture medium for various fungi, notably *Aspergillus* and *Penicillium* spp., and other organisms which contain a potent tannase enzyme. After these organisms have grown in an extract of waste tea, gallic acid, phloroglucinol and tannase may be obtained from the spent culture medium. Using a special mixture of organisms, extracts of tea with added sugar may be fermented to a palatable tea cider, containing about 1% of alcohol. Attempts have been made from time to time to encourage the production of tea cider on a large scale, but these attempts have so far been unsuccessful. Instant tea has also been produced from waste tea, and conversion of the entire supply of waste tea to this product would yield an estimated one million kg of cold-soluble instant. This may be worthy of consideration as the most profitable use for waste tea.

All of the points dealt with so far relate to products obtainable from the leaves of the tea plant. Examination of other parts of the tea plant has revealed that bark contains the tannins, corilagin, chebulinic acid and glucogallin. These tannins occur in small quantities in other parts of the tea plant as well, but their relatively higher concentration in the bark suggests that this material may find used in the tanning industry as a substitute for wattle bark tannin, which is being imported at the present time. Laboratory experiments, using hide powder showed that this powder was tanned by tea bark extract, and that the tannin-protein complex was quite stable. It remains to be seen whether tea bark extract is commercially useful, but experiments carried out a few years ago with extracts of waste tea gave encouraging results in that the experts at the Ceylon Leather Products Corporation were of the opinion that it may be suitable in cases where an open leather was required. These experiments are now continuing, and their outcome will be of interest, as this possible use has not been exploited as yet.

Another potentially useful part of the tea bush is tea seed. Tea seed contains valuable compounds which have not, as yet, been exploited in Ceylon these are tea seed oil and tea saponin. The content of oil is about 20%, and is remarkably similar to olive oil in chemical composition. It has been found to contain 72% oleic acid and 15% linolenic acid, both of which can, if required, be hydrogenated to stearic acid. This stearic acid could be made use of by institutions such as the Ceylon Tyre Corporation. It is estimated that it will be possible to obtain 100 Kg of tea seed per hectare, if small-holders are encouraged to concentrate exclusively on the production of tea seed. Seventy percent of the oil is in the kernel of the tea seed and 30% in the shell, and apart from being a superior cooking oil, it has a variety of other use. The tea seed cake remaining after oil extraction contains another valuable product, saponin, in appreciable quantity (10 to 15%). Saponins are compounds which foam strongly when shaken with water, and the saponins from the Mexican cactus, *Yucca* sp. is used in the beer industry for the production of a long-lasting foam. Saponins are practically non-toxic to man upon oral ingestion, but act as powerful haemolytics when injected into the blood stream, dissolving the red blood corpuscles even at extreme dilutions. It is on account of this heamolytic property that the Veddahs of Ceylon, and aborigines of other countries, have used saponin-containing fruits and leaves to kill fish. Saponins are also used in the formation of oil-in-water emulsions, preparation of hair shampoos, antiseptics and cough drops. They are also invaluable in the sensitization of photographic emulsions and this, may be the most profitable line to pursue. Chemically, saponins consist of two moieties, one of which is the sapogenin, and the other a mixture of sugars. The sapogenin moiety

may be a steroid or a triterpenoid, whilst the sugars, may be a hexose, a pentose or a methyl pentose. In tea saponin, the sapogenin moiety is triterpenoid in nature and has been well characterized by Japanese workers, whilst the sugars have been identified as glucose, fructose, rhamnose and arabinose, together with uronic acid.

The residue after extraction of oil and saponin forms about 60% of the original seed material, and contains about 2% N, 0.5% P and 2% K. Its high content of protein, (12.6%), indicates that it would be useful as a cattle feed, especially in view of its having been found to contain all the essential amino acids.

Saponin also occurs in tea roots, which contain about 5% of this compound, and this finding merits consideration when extensive uprooting programs are undertaken. The root residue after extraction of saponin has not been investigated as yet, but may serve as a source of nitrogen for fertilizer and animal feeds.

Coming back now to the black tea of commerce, work in the Soviet Union has indicated that the tea beverage may have important clinical applications. The most dramatic of these is in the prevention of atherosclerosis, which the Soviets attribute to a compound which they have named Vitamin P. Workers in California, too, have obtained evidence that the degree of atherosclerosis in rabbits fed with tea was significantly less than in those fed with coffee. This evidence is presently being tested by the Medical Research Institute and Tea Research Institute in collaboration, where an effort is also being made to determine which particular group of constituents in tea are responsible for any anti-atherosclerotic effect. The Russian workers obtained evidence that Vitamin P was a catechin, and they also claim, on the basis of experiments with mice, that catechins neutralize the effects of Sr^{90}, one of the most dangerous isotopes in radio-active fallout. Tea also contains appreciable quantities of fluoride and is therefore useful in the prevention of dental caries. The summary of the uses and by-products of tea and the tea bush are given in Table 1.

TABLE 1 — *By-products of tea*

Source	Product
Leaf	Black tea
	Green tea
Waste tea	Instant tea
	Caffeine
	Food colours
	Culture Medium
	Tea Cider
	Tannin
Bark	Tannin
Seed	Oil
	Saponins
	Residue for animal feed
Root	Saponin
	Residue for animal feed or fertilizer
Tea beverage	Clinical uses
	eg atherosclerosis
	dental caries
	radiation disease
	dysentery