# Darkening Effect of High Iron Honey on Tea

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HONEY finds various food uses as an alternative sweetener to table sugar (sucrose). For example, a teaspoon or two in a cup of tea provides not only sweetness, but also desirable flavor and aroma characteristics.

Recently, we received an imported honey sample from a concerned importer after a consumer of this honey found it to turn tea black. This honey (extra light amber) had been imported from China and its floral source was said to be milk vetch *(Astragalus sinicus)*. We investigated the cause of this color formation.

We first decided to analyze this honey for its iron content, as even the very early chemical literature described the formation of blue-black pigments when iron was allowed to interact with solutions of tannins. Tannins, or polyphenolics, are the dominant class of organic compounds that occur in tea. Pliny, in his Naturalia Historia (79 A.D.), used vegetable tannins as a qualitative test for iron,[1] and the reaction is commercially important in the production of inks and dyes. Early this century, Browne[2] reported that iron salts produced intense colors when added to 25 of 92 honey samples, and the most intense colors were produced in the darkest honeys. Honeys, therefore, also presumably contain tannins, as these materials are ubiquitous in the plant kingdom and in plant-derived materials.

The quantities of tannins in honey are very small compared to those in tea. Little is known about the reason for variability in color among honeys. Perhaps the natural levels of iron and tannins in honey play a major role. Milum,[3] in 1939, attributed at least part of the increase in color of honeys during storage to reaction of iron from processing equipment and containers with polyphenolic compounds.

The only study of levels of iron in honey was reported in 1932 by Schuette and Remy.[4] Light honeys averaged 2.4 parts per million (ppm) and dark honeys 9.4 ppm. More recently, Hase *et al.*[5] analyzed 190 honey samples for iron and found them to range from 0.3 to 44.2 ppm, with just two samples having over 40 ppm. In their analysis of 170 domestic and imported samples, iron levels ranged from 1.3 to 360 ppm. Thirteen of these samples contained between 30 and 100 ppm iron, and eight had iron levels exceeding 100 ppm. The imported honey sample in the present study was analyzed by atomic absorption spectroscopy and contained 42 ppm iron. This is an unusually high level, which was especially surprising since this honey was extra light amber in color.

Following are listed the experiments we conducted to establish that it is indeed the high level of iron in the sample of milk vetch honey which is responsible for darkening tea. Cups of tea were prepared by stirring one tea bag in 200 milliliters of boiling water for 2 minutes, and 1 level teaspoon of honey weighed 11.9 grams. For most experiments another honey, a dark amber mixed wildflower honey containing 10.4 ppm iron was used for comparison. From here on, this honey is referred to as **B**, and the high iron honey (milk vetch) **A**.

I. One teaspoon (11.9 grams) each of honeys **A** and **B** were added with stirring to separate cups (200 milliliters) of tea. **A** darkened the tea very quickly, while **B** had no effect. Intensity of colors was conveniently measured on a spectrophotometer, at a wavelength of 550 nanometers, with tea used alone to zero the instrument. Ninety per cent of the color development occurred within 30 seconds. Such a rate suggests that an inorganic reaction is occurring. Adding **A** to cold tea also quickly darkened the tea.

II. **A** (2 teaspoons) was diluted with 4 parts water, then stirred overnight with a cation exchange resin in the hydrogen form [IR-120(H+)]. This resin removed iron (ionic form) from **A** and replaced it with hydrogen ions. After removal of the resin (containing the iron) from the honey solution, no darkening was caused when the honey was added to 1 cup of tea. This is convincing evidence for the role of iron.

III. A 0.1% solution of tannic acid (digallic acid) was prepared by dissolving 0.1 gram in 100 milliliters of water. This compound is chemically similar to the variety of polyphenols present in tea, collectively termed tannins. A teaspoon of honey **A** quickly darkened this solution, while **B** did not. As would be expected, a solution of an iron compound, ferric chloride, also darkened the tannic acid solution. Honeys **A** and **B** were distinguished in this experiment because of their different levels of iron.

IV. A solution of an iron containing salt, ferric chloride, was prepared which

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contained 50 micrograms of iron per 10 microliters water. This was added in increments, with stirring, to 50 milliliters of tea. After each addition, the color intensity was read off the spectrophotometer (550 nanometers), again with tea used to zero the instrument. The results of this experiment are given in fig. 1, where it can be seen that addition of these small portions of iron greatly darkens the tea.

V. Honeys **A** and **B** were added in increments to 50 milliliters of tea, with stirring. Readings were taken from the spectrophotometer after each addition, and the results are shown in fig. 2. Honey **A** darkened the tea more quickly than did honey **B**. Tea-honey mixtures with absorbances greater than 0.200 are dark to the eye. In this experiment, corrections were made for the contributions to color by the honeys themselves, without iron. Honey **B**, being dark amber, would darken tea somewhat even without the contribution of its iron. From the absorbances of tea after addition of various weights of **A** and **B** (fig. 2), iron levels in these honeys can be approximated by reading levels for corresponding absorbances from fig. 1. For honey **A**, this method gives a level of 41-51 ppm and for honey **B**, 17-21 ppm. Though this is not as precise a method, these values are in quite good agreement with those determined by atomic absorption spectroscopy. It appears that a convenient method for estimating iron levels in honeys could be developed by titrating them into standard tannic acid solutions.

There is little doubt that the high level of iron in the imported honey sample is responsible for its adverse interaction with tea. While the low pH of honey (3.9) and its organic acid content would favor the mobilization of iron from a low quality steel drum during prolonged storage, it is likely that this sample of milk vetch honey from the comb had the high level of iron. Perhaps this honey was low in tannins, allowing the unassociated iron to interact with tea tannins, causing the darkening effect.

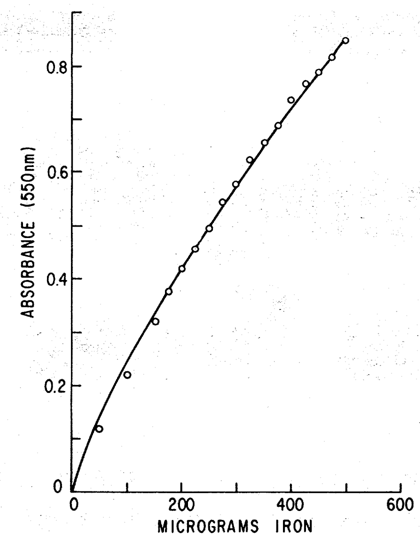


**Fig. 1. Effect of ferric chloride addition on the darkening of tea.**

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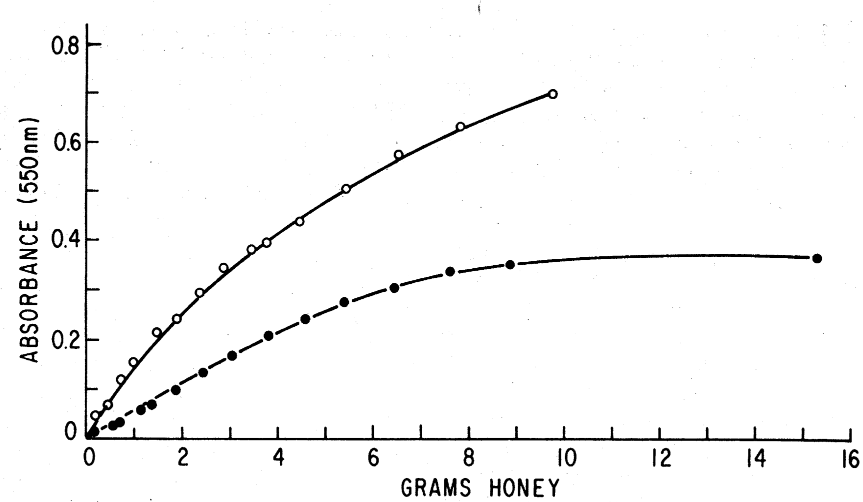


**Fig. 2. Effect of adding honey A (high iron, o———o) and honey B (low iron, •———•) on the darkening of tea.**