Abstract:Mythbuster
Episode KIDNEY STONE
Never Eat Spinach and Tofu Together?

Background

There is a common saying that when someone eats spinach and tofu at the same time, the chance of having a kidney stone increases.
Tofu and spinach are natural sources of calcium ion (Ca^{2+}) and oxalate ion ($C_2O_4^{2-}$) respectively. Meanwhile, CaC_2O_4 is the main content of kidney stone.
In this project, we mimic the formation of kidney stone by combining calcium chloride ($CaCl_2$), to sodium oxalate ($Na_2C_2O_4$), forming CaC_2O_4 solid that is similar to typical kidney stone.

Figure: Spinach (left) and tofu (right) as natural sources of calcium and oxalate

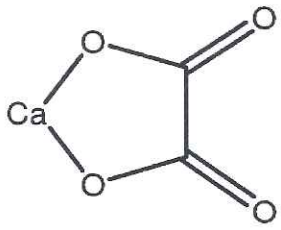


Figure: Structural formulae CaC_2O_4

Objectives

In this project, we will investigate the following:

A. The possibility of formation of calcium oxalate kidney stone by direct consumption of calcium ion and oxalate in foods.

   I. Formation of CaC_2O_4 under mediums of different pH value

$$Ca^{2+}_{(aq)} + C_2O_4^{2-}{}_{(aq)} \rightarrow CaC_2O_{4\,(s)}$$

B. The effectiveness of treating calcium oxalate kidney stone by using EDTA and citric acid as medicines.

II. Effectiveness of treating kidney stone with Ethylenediaminetetraacetic acid (EDTA) under mediums of different pH values
III. Effectiveness of treating kidney stone with citric acid under mediums of different pH values
IV. Differences of using EDTA and citric acid to treat kidney stone

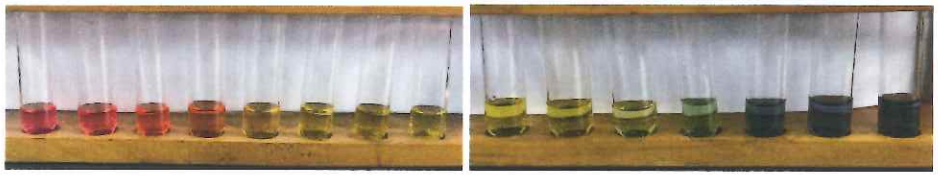


Figure: A spectrum shown by universal indicator under different pH values (From most acidic to most alkaline)

Significance of the project

First, the report exhibits the possibility of formation of kidney stone in different parts of alimentary canal under different pH values. We showed that intaking Ca^{2+} ion and oxalate ion in food will not cause the absorption of Calcium oxalate in the alimentary canal as Calcium oxalate can only form in pH 2-14.

pH	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Precipitation?	✗	✗	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

(A ✗ sign represents no precipitation)
(A ✔ sign represents precipitation)

Second, the report stimulate kidney stone treatment with EDTA and citric acid. We found out that EDTA is a very effective treatment as all kidney stones dissolves with the addition of EDTA. However, despite the addition of citric acid, it cannot dissolve Calcium oxalate effectively, but it can dissolve Calcium hydroxide in pH 13-14.

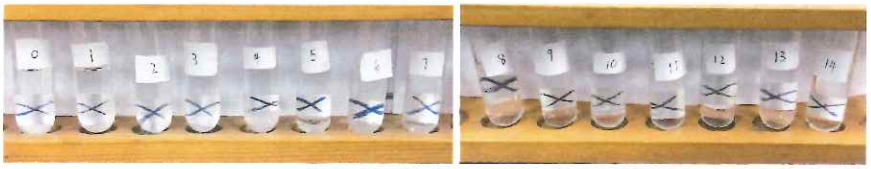


Figure:EDTA treatment under pH value 0-14

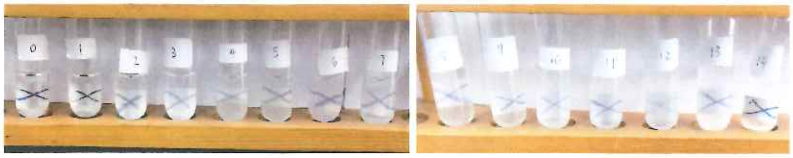
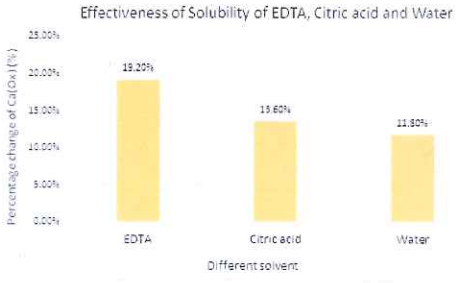


Figure: Citric acid treatment under pH value 0-14

Third, the report compares the effectiveness of EDTA, citric acid and water in dissolving Calcium oxalate. By comparing their differences in dry mass, we found that EDTA was very effective, following with citric acid and water.



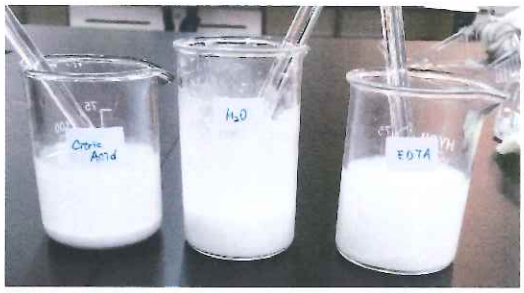


Table: A graph showing the effectiveness of EDTA, Citric acid and Water(left)
Figure: Mixtures of CaC_2O_4 and different solvents(right)

Conclusion

From the investigation, we showed that direct consumption of calcium ion and oxalate would not cause kidney stone. Since calcium and oxalate form precipitate in human small intestine, the precipitate formed would not be absorbed as it cannot pass through the wall of alimentary canal. Therefore, the common saying that eating spinach and tofu together leads to kidney stone is considered **unreal.**

Also, the abilities of EDTA and citric acid as a medicine to treat kidney stone have been tested and compared. To conclude, EDTA can be used as an effective medicine, while citric acid supplement or direct consumption of citrous fruit can also be an effective preventive measure in long terms to prevent forming kidney stone.

Figure: EDTA medicine (left) / Citric acid supplement (right)