



CALIFORNIA STATE SCIENCE FAIR 2002 PROJECT SUMMARY

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Project Title "Aluminum Soup": The Absorption of Aluminum and Iron into Citric Acid Solutions Boiled in Metal Cookware	
Objectives/Goals Are we unknowingly consuming toxic metals when we eat foods cooked in metal pots and pans? The objective of this experiment was to determine whether significant amounts of aluminum or iron could be absorbed from metal cookware into boiling solutions of 1% or 2.5% citric acid or distilled water (the control). Citric acid is the main acid in tomatoes and citrus fruits. Abstract Methods/Materials Two liters of 1% and 2.5% citric acid solutions and distilled water were boiled for 30 minutes in an iron skillet, an aluminum pot, a stainless steel pot, a Teflon pot, and a scratched Teflon pot. Samples of each solution were assayed for levels of iron using an atomic absorption spectrophotometer at the University of San Diego. Samples from the aluminum and scratched Teflon cookware were assayed for levels of aluminum by the Environmental Engineering Lab. The results were compared to health and toxicity standards for daily allowable intakes of iron and aluminum. Results Low levels of iron (less than 0.53 mg/L) were absorbed from the aluminum, stainless steel, Teflon, and scratched Teflon cookware. Significant amounts of iron were extracted from the iron skillet into the 1% and 2.5% citric acid solutions at 53.7 and 181.2 mg/L respectively. Significant amounts of aluminum were absorbed into the 1% and 2.5% citric acid solutions from the scratched Teflon pot (at 3.13 and 6.35 mg/L respectively) and the aluminum pot (at 17.2 and 54.5 mg/L respectively.) Conclusions/Discussion Stainless steel and unscratched Teflon cookware appear safe to use when cooking foods that contain citric acid. In fact, the low levels of iron absorbed from the stainless steel pot, the aluminum pot, and the Teflon and scratched Teflon cookware may contribute to the recommended dietary allowance of 10-15 mg/day. The larger amounts of iron absorbed from the iron skillet at 53.7-181.2 mg/L, however, are aesthetically objectionable and may approach levels of toxicity. Significant levels of aluminum were extracted from the scratched Teflon pot and the aluminum pot at 3.13 to 54.5 mg/L. These amounts greatly exceed the US NSDWR standard and are 5 to 55 times the California EPA primary or health-based maximum contaminant level (MCL) for aluminum in drinking water. These levels are sufficient to adversely affect taste and odor and may provide unnecessary exposure to aluminum in the diet that may contribute to unknown and possibly adverse health effects.	
Summary Statement This project investigates the absorption of aluminum and iron into citric acid solutions boiled in metal cookware and compares the results to health and toxicity standards.	
Help Received Thanks to Carole Ziegler at the University of San Diego for inviting and allowing me to use the atomic absorption spectrophotometer at the USD Environmental Studies Lab and to Robert Chambers at the Environmental Engineering Lab for the lesson on inductively coupled plasma spectrometers.	