The chemistry of reverse impurity diffusion and food contamination during cooking in three-legged aluminum pots.

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Introduction

The three-legged aluminum pots artisanal green sand cast are popular in African countries, particularly in South Africa, where they serve various functions including cooking meals and feeding communities during ceremonies. From melting aluminum scrap at about 660 0C to pouring into silica mold, with a higher percentage in aluminum, scraps from various sources like car wrecks and discarded appliances may display a diversity of chemical compositions (Al, Pb, Si, Ti, Fe etc..). Many of these elements end up in the cast as oxides or their derivatives, that once in contact with the food acidity under the cooking high temperature may dissolve in the food being cooked.

Objectives

- To determine the 3-legged aluminum pot contamination into food.
- To identify if Spinach properties foster the alloys leaching levels.
- To identify if prolonged exposure to heat impacts the diffusion kinetics.

Key Variables

Type of food acidity
Cooking duration
Cooking temperature
Pot chemical compositions

Methodology

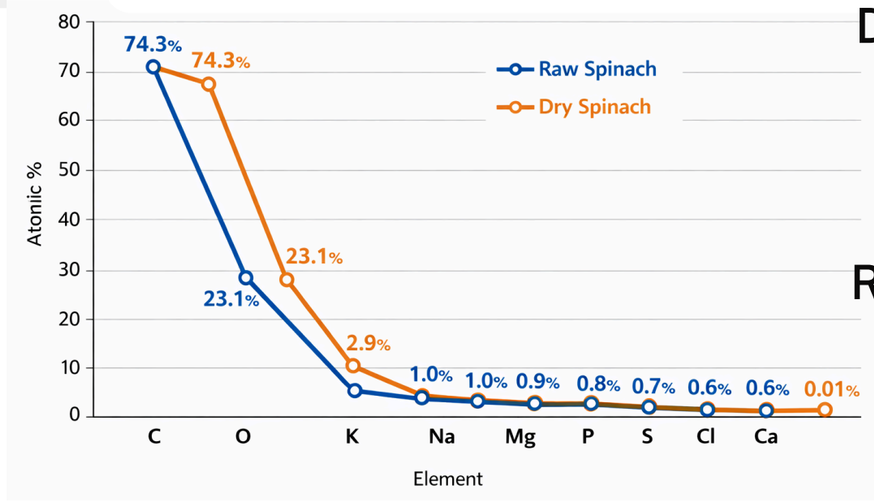
Approach : Experimental research
Sample : Spinach, deionized water, green sand cast three-legged aluminium
Data collection: Systematic
Analysis Tool: AAS (Atomic Absorption Spectroscopy) & SEM (Scanning Electron Microscope) and XRF (X-rays flourescence).

Results & Discussion

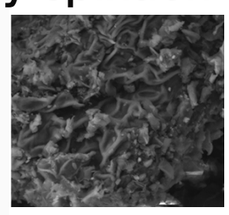
• Spinach's chemical composition includes oxalic acid ($C_2H_2O_4$).
• Its properties make it a significant element for the study.
• Corrosion in handcrafted aluminum pots is primarily caused by the breakdown of the protective aluminum oxide coating (Al_2O_3).
• This breakdown occurs due to exposure to acidic or alkaline meals.

Data Table

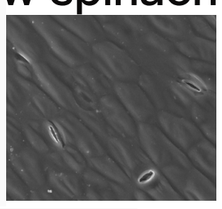
Sample ID	Signal (Abs)	RSD (%)	Conc. (mg/L)	Corrected - Conc. (mg/L)
120 min	0.001373	13.92	0.106	0.106
90 min	0.006266	2.86	0.555	0.555
60 min	0.000491	10.45	0.025	0.025
30 min	0.000311	154.65	0.0086	0.0086
Fresh Spinach	0.014228	2.45	1.277	1.277
Old Spinach	0.003378	3.37	0.695	4.172



Dry spinach



Raw spinach



Conclusion

Concentration profiles show metal leaching from aluminum cookware into spinach.
• Reverse diffusion and re-adsorption of ions occur in aged samples.
• Old spinach displays a significantly high concentration of approximately 4.17 mg/L.
• Indicates secondary contamination due to surface oxidation and organic degradation products.
• Confirms dynamic exchange between the cooking vessel and food medium.

SEM analysis:
• Spinach's composition is carbon-rich and contains oxygen.
• Dried spinach has increased chemical activity towards aluminum due to the more concentrated minerals as a result of less water.
• Potassium and other salts enhance ionic strength.
• Higher ionic strength can accelerate aluminum corrosion and leaching from cookware.

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