

# Stainless Steel Leaches Nickel and Chromium into Foods During Cooking

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## Introduction

Toxicological studies show that oral doses of nickel and chromium can cause cutaneous adverse reactions such as dermatitis. Additional dietary sources, such as leaching from stainless steel cookware during food preparation, are not well characterized. This study examined stainless steel grades, cooking time, repetitive cooking cycles, and multiple types of tomato sauces for their effects on nickel and chromium leaching. Trials included three types of stainless steels and a stainless steel saucepan; cooking times of 2 to 20 hours, ten consecutive cooking cycles, and four commercial tomato sauces. After a simulated cooking process, samples were analyzed by ICP-MS for Ni and Cr. After six hours of cooking, Ni and Cr concentrations in tomato sauce increased up to 26- and 7-fold respectively, depending on the grade of stainless steel. Longer cooking durations resulted in additional increases in metal leaching, where Ni concentrations increased 34 fold and Cr increased approximately 35 fold from sauces cooked without stainless steel. Cooking with new stainless steel resulted in the largest increases. Metal leaching decreases with sequential cooking cycles and stabilized after the sixth cooking cycle, though significant metal contributions to foods were still observed. The tenth cooking cycle, resulted in an average of 88 µg of Ni and 86 µg of Cr leached per 126 g serving of tomato sauce. Stainless steel cookware can be an overlooked source of nickel and chromium, where the contribution is dependent on stainless steel grade, cooking time, and cookware usage.

## Study Design

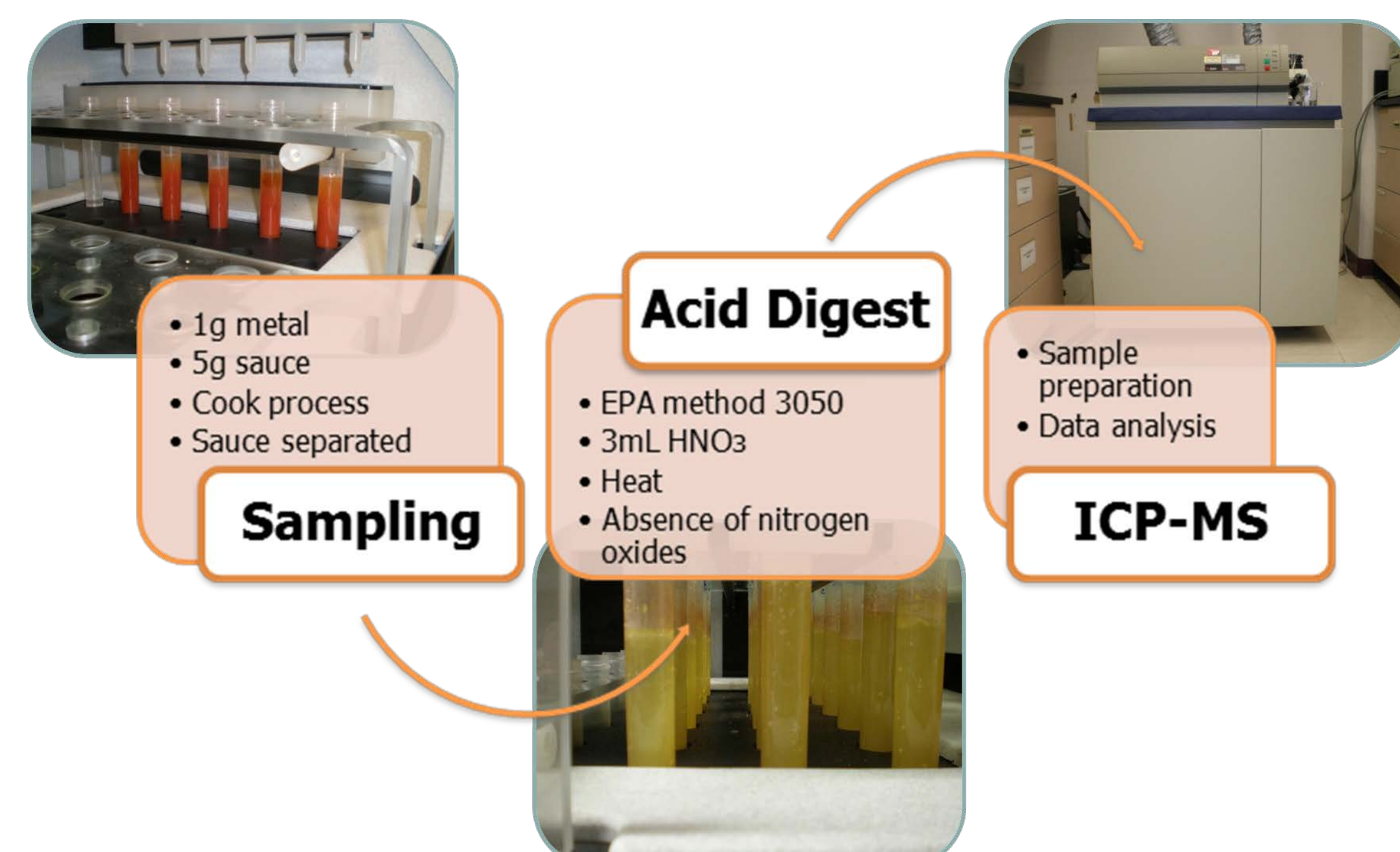
Stainless Steel Grade	Saucepan	Cooking Time
<ul style="list-style-type: none"> <li>Materials: NIST SRMs, NI-131</li> <li>Cook time: 6 hr</li> <li>Cycles: 1</li> <li>Tomato sauce : 1</li> </ul>	<ul style="list-style-type: none"> <li>Materials: Grade 316</li> <li>Cook time: 20 hr</li> <li>Cycles: 1</li> <li>Tomato sauce: 1</li> </ul>	<ul style="list-style-type: none"> <li>Materials: NIST 123c</li> <li>Cook time: 2, 6, 20 hr</li> <li>Cycles: 1</li> <li>Tomato sauce: 1</li> </ul>
Cooking Cycles	Commercial Tomato Sauce	
<ul style="list-style-type: none"> <li>Materials: NIST 123c</li> <li>Cook time: 6 hr</li> <li>Cycles: 10</li> <li>Tomato sauce: 1</li> </ul>	<ul style="list-style-type: none"> <li>Materials: NIST 123c</li> <li>Cook time: 6hr</li> <li>Cycles: 1</li> <li>Tomato sauce: A,B,C,D</li> </ul>	

## Materials

Identification Number	Stainless Steel Grade Equivalence	Chemical Composition (mass fraction %)	
		Cr	Ni
NIST 121d	304	17.50	11.18
NIST 123c	304	17.40	11.34
NIST 160b	316	18.34	12.35
NI-131	—	—	99.9
Saucepan*	316	16 - 18	10 - 14

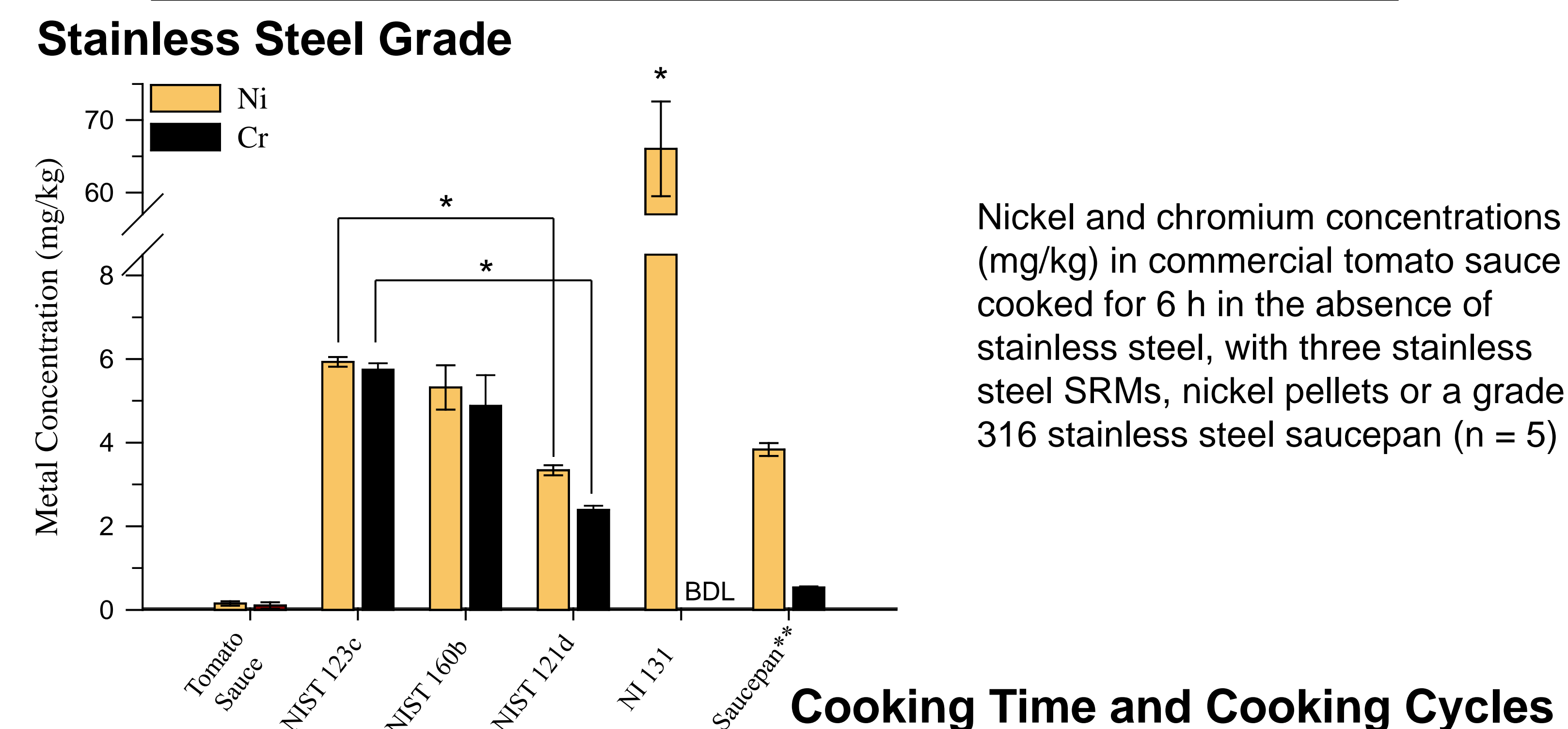
\* Saucepan Ni and Cr concentrations estimated range taken from Atlas Steel 2000.

## Methods

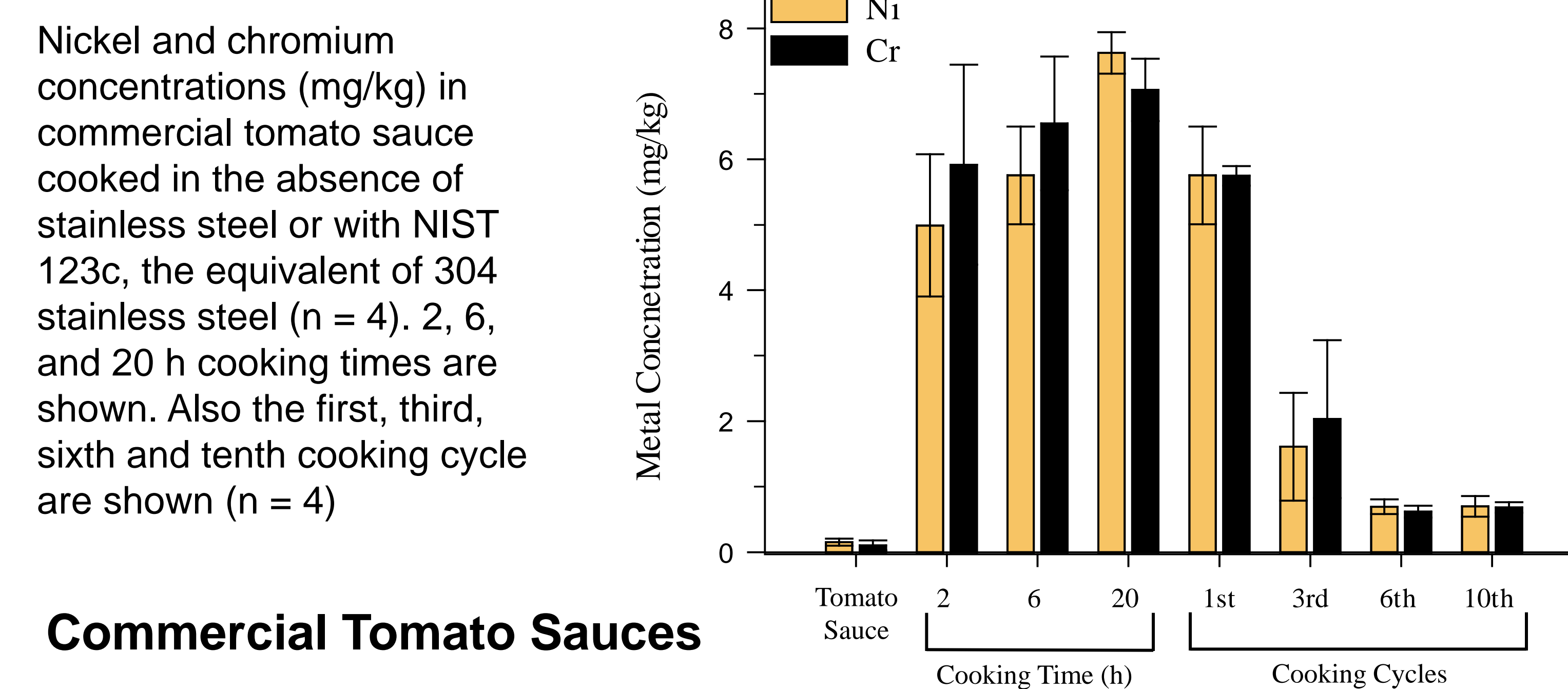


## Results:

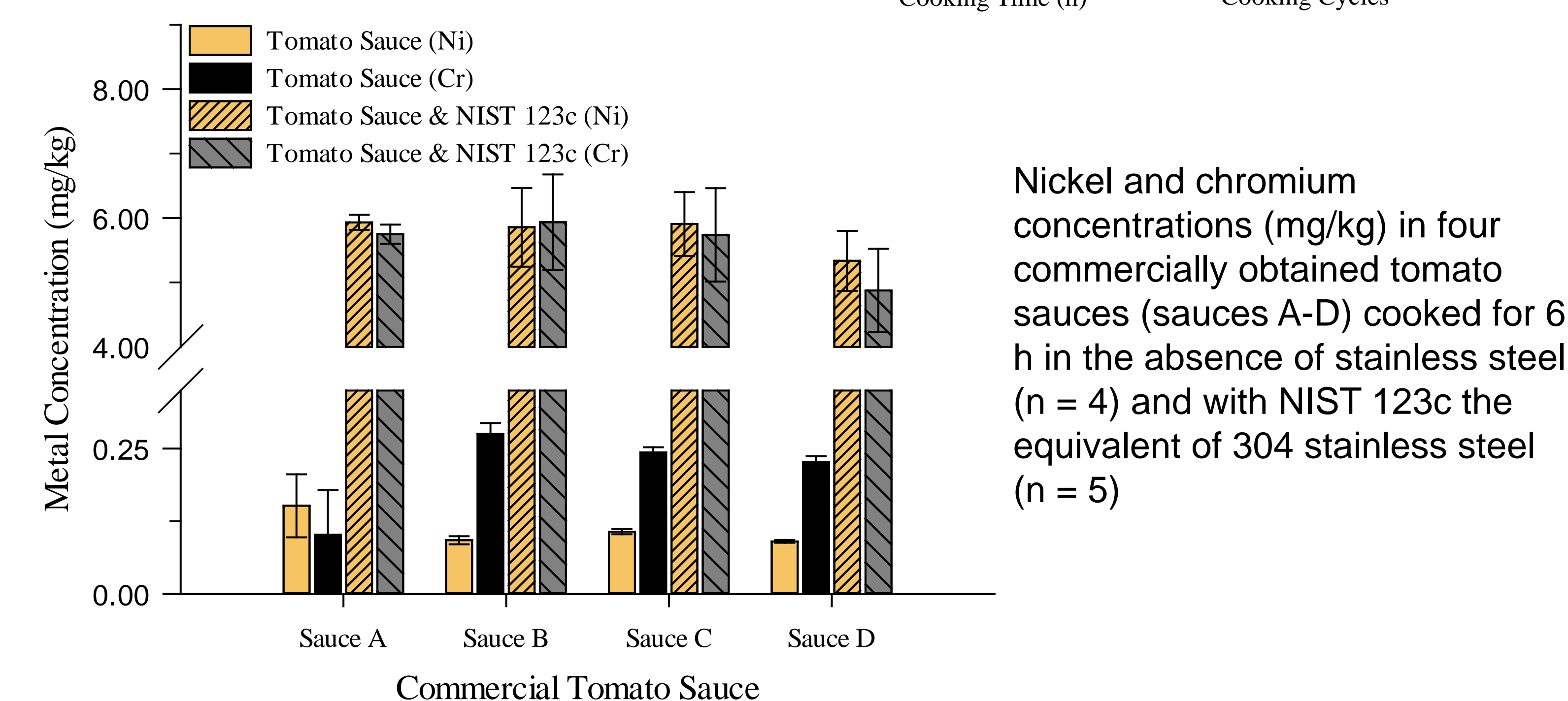
### Metal Released from Stainless Steel into Tomato Sauce



### Cooking Time and Cooking Cycles

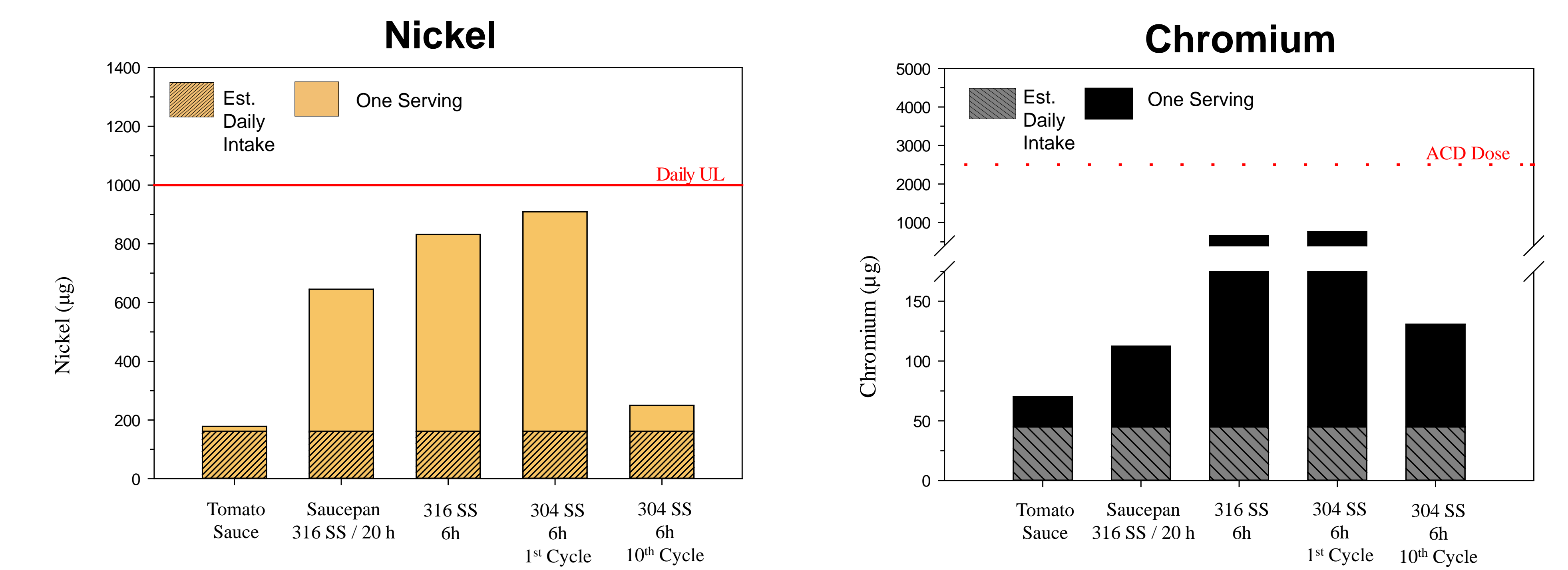


### Commercial Tomato Sauces



## Discussion

### Total daily intake for Ni and Cr and potential contributions from cooking scenarios



Potential (A) nickel (µg) and (B) chromium (µg) from one serving (126 g) of tomato sauce from various cooking scenarios in addition to estimated maximum daily nickel intakes for U.S. adults (162 µg/day) (1) and adequate chromium intake level of a healthy individual, 45 µg/day (2). Nickel levels are compared with the Tolerable Upper Intake Level (UL) (1000 µg/day) (3) and chromium levels are compared with the lowest dose known to cause ACD, 2500 µg/day (4).

## Conclusions

- Different SS grades have different leaching properties in tomato sauce. The mass of Ni in stainless steels did not correlate with the amount leached.
  - NIST 160b has a larger Ni mass fraction than the other SS tested; however, we observed that it did not have the largest amount of Ni leached considering both Ni mass or %Ni leached.
- Longer cook times in the first cooking cycle produced statistically higher Ni and Cr leaching concentrations at 20 h consistent with findings for other metals and cookware
- Seasoning of the SS samples, through multiple cook cycles reduced the amount of Ni and Cr leached, although it did not eliminate either.
- Commercial tomato sauces did not show significant differences of nickel and chromium leaching.
- Nickel and chromium released from stainless steel can significantly contribute to overall dietary exposure.
  - In addition to dietary restrictions, nickel and chromium exposure can be reduced by avoiding the use of stainless steel cookware.

### References

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- Velen, N. K.; Hattel, T.; Justesen, O.; Norholm, A., Oral challenge with metal salts. (I). Vesicular patch-test-negative hand eczema. Contact Dermatitis 1983, 9, 402-406.