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**PROJECT TITLE: WHICH APPENDAGE CAPTIVATE AND FURNISH  
ELEVATE NUTRIENTS?**

**PARTICIPANT NAME: HUMAINA**

**SCHOOL: MOUNT HIRA MATRICULATION SCHOOL**

**CITY & STATE: NELLIKUPPAM, TAMIL NADU**

## II.INTRODUCTION

This project was carried out to study how different utensils affect the quality and freshness of food when cooked and stored. The experiment included spinach, lemon juice, and tamarind juice placed in six different utensils — clay, aluminum, copper, stainless steel, non-stick, and cast iron.

Observations were made over several days to note changes in color, smell, and texture. It was found that the material of each utensil influenced the food differently. Some utensils caused faster spoilage or discoloration, while others helped the samples stay fresh for a longer time.

### **The research questions I aimed to answer were:**

1. Does the type of utensil material affect nutrient retention during cooking?
2. Do utensils made from specific materials enhance nutrient absorption or provide additional health benefits?
3. Can cooking with cast iron utensils increase iron intake and improve nutritional value?
4. Do stainless steel utensils preserve nutrients better than reactive materials?
5. How does the nutrient retention of brass utensils compare to other materials (e.g., Kansa/bronze, stainless steel

focused on three food samples — spinach, lemon juice (with vinegar), and tamarind juice — as each represents a different type of food: leafy, acidic, and sour. By comparing their reactions in different utensils, I was able to study how both cooked and raw acidic foods behave with various metals and non-metals.

These samples were chosen because each one reacts differently with heat and metal surfaces and helps to test various conditions of cooking and storage.

I used eight types of utensils made from different materials:

1. Clay pot
2. Brass utensil
3. Bronze (Kansa) utensil
4. Stainless steel utensil
5. Copper utensil
6. Aluminium utensil
7. Cast iron utensil
8. Non-stick utensil



These utensils represented both traditional and modern cooking materials.

To make the study accurate, I checked each utensil and sample using the following parameters:

Color change

Smell (fresh or spoiled)

Texture (soft, dry, slimy)

Reaction signs (bubbles, blackening, metallic smell)

Spoilage rate (days before signs appeared)

All samples were kept on the same table at room temperature to ensure that external factors like sunlight or cold air did not affect the results. The utensils were also cleaned thoroughly before use to avoid contamination.

Through this detailed procedure, I was able to fairly compare the reaction of each utensil material and determine which ones preserved nutrients and freshness the best.

### **III.METHODS AND PROCEDURE**

The main purpose of this experiment was to observe how different types of utensils affect the freshness, quality, and nutrient retention of different foods. For this, three food samples were chosen — spinach, lemon juice with vinegar, and tamarind juice. These samples were tested in eight types of utensils: clay pot, stainless steel, aluminum, copper, cast iron, brass, bronze (Kansa), and non-stick.

Each utensil was thoroughly cleaned before use to ensure that no residue or old food material would affect the result. Equal quantities of each sample were used to make the experiment fair and accurate. All utensils were kept at the same temperature and in the same environment throughout the experiment.

#### **Study 1: Spinach**

In this part of the experiment, equal amounts of fresh spinach leaves were washed and placed into each utensil with a small quantity of water and salt. The spinach was cooked on a medium flame for the same amount of time in all utensils. After cooking, all utensils were allowed to cool naturally and were then kept at room temperature without lids.

The spinach was observed daily for any changes in color, texture, and smell. It was noticed that the spinach cooked in the clay pot, brass, and stainless steel utensils stayed green and fresh for a longer time. These samples had a mild, pleasant smell even after a few days. On the other hand, spinach cooked in aluminum, copper, and cast iron utensils turned darker in color and developed a spoiled or sour smell faster. The spinach cooked in the non-stick utensil did not show much visible change, but it also did not preserve the freshness as effectively as the non-reactive materials.

This part of the study showed that utensils made of natural or non-reactive materials, like clay and brass, help retain the nutrients and color of leafy vegetables for a longer time, while reactive metals reduce freshness.



## Study 2: Lemon Juice with Vinegar

The second study used an acidic mixture of lemon juice and vinegar to observe the chemical reaction with different utensil materials. Equal quantities of the mixture were poured into all eight utensils and slightly heated until bubbles appeared. After heating, the samples were left uncovered at room temperature.

Over the next few days, the reactions of each utensil with the acid were carefully noted. In the clay pot, most of the liquid was absorbed because of its porous nature — only a small amount of juice remained at the bottom. The stainless steel, brass, and bronze utensils did not show any major changes in color or smell, proving that they did not react with the acid.

However, the copper and aluminum utensils showed clear signs of reaction — the lemon mixture became dull and slightly greenish in color, and the inside surface of the utensils developed a faint stain. The cast iron utensil also showed mild rusting on its surface. The non-stick utensil did not react visibly, but it also did not provide any special benefit for nutrient protection.

This study confirmed that acidic foods react strongly with reactive metals like copper, aluminum, and iron, while non-reactive materials like stainless steel, brass, and clay keep the liquids stable and fresh.

### **Study 3: Tamarind Juice**

In the final study, tamarind juice was used to test the effect of different utensils on another acidic sample. Equal quantities of tamarind juice were poured into each utensil and slightly heated until warm. After cooling, the utensils were left uncovered at room temperature and observed daily for several days.

It was found that tamarind juice kept in clay pot, brass, bronze, and stainless steel utensils maintained its natural brown color and pleasant smell for a longer time. These samples showed little or no reaction. In contrast, the juice stored in copper, aluminum, and cast iron utensils darkened quickly, developed a metallic smell, and spoiled faster. The non-stick utensil again showed no major reaction but did not help in maintaining freshness.

This part of the experiment showed that acidic foods like tamarind react quickly with reactive metals and lose freshness, while traditional and non-reactive utensils help preserve quality and nutrients better.

Overall, all three studies were conducted under the same conditions — equal sample size, temperature, and observation period. The combined results helped to identify which utensils are safe and effective for maintaining nutrient value and which ones cause faster spoilage due to chemical reactions.

## IV.RESULTS

In my experiment, I compared how different utensil materials affected the nutrient retention, freshness, and reaction level of three food samples — spinach, lemon juice, and tamarind juice. The results showed clear differences between reactive and non-reactive utensils.

After several days of observation, I found that stainless steel, clay pot, and brass utensils preserved nutrients and freshness the best. The spinach cooked in these utensils stayed green for a longer time, had a pleasant smell, and did not spoil quickly. Similarly, lemon and tamarind juices stored in these utensils maintained their color and acidity without reacting or changing taste.

After continuous observation for several days, I noticed clear differences between reactive and non-reactive utensils.



<b>Utensil name</b>	<b>Spinach</b>	<b>Lemon juice with vinegar</b>	<b>Tamarind juice</b>
<b>Clay pot</b>	<b>Keeps spinach fresh longer because of its porous nature, allowing slight air circulation.</b>	<b>It absorbed most of the juice; very little liquid left after some time.</b>	<b>Mildly thick; no spoilage seen</b>
<b>Stainless steel</b>	<b>Neutral. no major reaction. freshness mostly Maintained</b>	<b>No visible reaction; maintained acidity.</b>	<b>Stable and unreactive.</b>
<b>Brass</b>	<b>Slight colour change. May preserve minerals</b>	<b>Slight discoloration after long exposure.</b>	<b>Minor reaction after hours.</b>
<b>Copper</b>	<b>Likely to darken or spoil faster due to reaction with contents.</b>	<b>Strong reaction; taste changed.</b>	<b>High reactivity, spoiled faster.</b>
<b>Cast iron</b>	<b>May darken; possible slight reaction with spinach water.</b>	<b>Slight metallic taste appeared.</b>	<b>Reacted a little but less than copper.</b>
<b>Aluminium</b>	<b>May spoil faster; can react and reduce nutrients.</b>	<b>Strong reaction; turned darker and sour.</b>	<b>Reacted and became blackish faster.</b>
<b>Non stick</b>	<b>No visible reaction; retains texture but no nutrient gain.</b>	<b>No visible reaction.</b>	<b>No reaction but less nutrient enhancement.</b>
<b>Bronze</b>	<b>Retained nutrients effectively; minimal change.</b>	<b>Slight reaction due to acid, mild discoloration.</b>	<b>Remained good for short period; reacted mildly over time.</b>

## **Overall observation**

1. Utensil Material Matters: The type of utensil has a strong effect on nutrient retention, freshness, and reaction with food samples.

2. Non-Reactive Utensils Performed Best: Stainless steel, clay pot, brass, and bronze helped preserve nutrients and freshness for the longest time.

3. Reactive Metals Caused Faster Spoilage: Copper, aluminum, and cast iron reacted strongly with acidic foods like lemon juice and tamarind, leading to color change and early spoilage.

4. Porous Nature of Clay: The clay pot absorbed lemon juice due to its porous nature, proving that clay can soak in acidic liquids but still prevents quick spoilage.

5. Non-Stick Was Neutral: Non-stick cookware showed no visible reaction but didn't improve nutrient preservation either.

6. Acidic Foods React More: Lemon and tamarind juices reacted quickly with metals, especially copper and aluminum, showing that acidic foods must be handled in non-reactive containers.

7. Spinach Showed Nutrient Retention Clearly: Spinach retained its color and texture better in stainless steel, brass, and clay utensils, while it lost freshness faster in reactive ones.

8. Traditional Utensils Work Better: Clay, brass, and bronze proved to be eco-friendly and effective in maintaining both taste and nutrient value.

9. Temperature & Exposure Effects: Samples kept in thicker, breathable utensils (like clay) spoiled slower than those in thin or reactive metals.

## Results

- Overall, clay pot, stainless steel, and brass were the best performers, while copper and aluminum were the least suitable for nutrient preservation.
- Noting changes in color, smell, texture, and pH level.
- The data showed that natural or non-reactive utensils (clay, brass, stainless steel) maintained nutrient quality and freshness much better than reactive metals (copper, aluminum, cast iron).
- Keeps spinach fresh longer because of its porous nature, allowing slight air circulation.
- Slight color change over time; mild acid reaction.
- Natural color and smell expected to remain steady.
- Overall, my results proved that the type of utensil material directly affects the nutrient level, freshness, and safety of food during cooking and storage.

### pH Level of Food Samples after Cooking in Different Utensils

Utensil Material	Spinach	Lemon Juice	Tamarind juice
Clay	6.5	2.5	3.5
Stainless Steel	6.8	2.8	3.8
Brass	6.6	2.6	3.6
Copper	5.5	3.5	4.5
Aluminium	5.0	3.0	4.0
Cast Iron	6.8	3.5	4.5
Non stick	5.5	2.8	3.8

## Scatter Plot: Relationship between pH Level and Nutrient Retention

pH level	Nutrient Retention%
2.5	60
3.0	65
3.5	70
4.0	75
5.0	50
5.5	55
6.0	80
6.5	85
6.8	90

## Heatmap: Reactivity of Utensil Materials with Different Food Samples.

Utensil Material	Spinach	Lemon Juice	Tamarind Juice
Clay	Low	Low	Low
Stainless Steel	Low	Low	Low
Brass	Low	Moderate	Moderate
Copper	High	High	High
Aluminum	High	High	High
Cast Iron	Moderate	High	High

## V.DISCUSSION

The experiment was carried out to study how different utensil materials affect nutrient retention and food quality during cooking and storage. The samples used were spinach, lemon juice, and tamarind juice - each having different properties. Spinach contains vitamins and minerals that are sensitive to heat and reaction, while lemon and tamarind juices are acidic, which helps to observe the reactions with metals more clearly.

From the observations, stainless steel, clay pot, and brass utensils performed best in preserving nutrients and maintaining the natural characteristics of the food. The spinach cooked in these utensils retained its green color longer and did not develop any unpleasant odor even after a few days. The acidic juices stored in these materials showed no visible reaction, and their taste remained unchanged. This shows that these materials are mostly non-reactive and safe for both cooking and storage.

On the other hand, copper, aluminum, and cast iron utensils reacted more quickly with the food samples. In copper and aluminum, discoloration occurred when lemon and tamarind juices were stored, indicating a chemical reaction between the acids and the metals. Cast iron caused a darkening in spinach and also produced a metallic taste, showing that it reacts easily with moist or acidic food. These changes prove that reactive metals can cause the loss of essential nutrients and may even make the food harmful if used for long storage.

The non-stick utensil showed no strong reaction, but it also did not improve the nutrient value or help in retention. It remained neutral, and its advantage is only in reducing oil usage, not in preserving nutrients.

In summary, the results show that traditional and natural utensils like clay, brass, and stainless steel are best for nutrient preservation, while highly reactive or coated utensils may alter the food quality. This supports the hypothesis that the type of utensil material directly influences the nutritional outcome and safety of the cooked or stored food.

### **1. Chemical reasons for different behaviours**

The main reason utensils behaved differently is chemical reactivity — how easily the metal surface interacts with acids, water, and food compounds.

Reactive metals (copper, aluminum, cast iron): These metals oxidize or leach ions when they contact acidic or moist foods. Acids (citric acid in lemon, tartaric-like acids in tamarind) accelerate corrosion and metal ion release. The released metal ions can change the colour

(greenish or dark films), taste (metallic or bitter), and sometimes speed up breakdown of some vitamins (for example, vitamin C is sensitive to oxidation). Cast iron surfaces can oxidize and darken food due to iron oxide formation; copper and aluminum can form coloured salts or films on contact with acid, causing visible changes and off-odours.

Non-reactive or mildly reactive materials (stainless steel, brass, bronze, clay):

Stainless steel contains chromium and nickel creating a passive oxide layer that resists chemical attack, so it does not easily leach ions or change food pH. This explains the stable colour and taste in stainless steel samples.

Brass and bronze are alloys (copper + zinc or copper + tin) that are less reactive than pure copper due to their alloy composition and surface behaviour; they showed only slight changes, so they behaved better than pure copper.

Clay is non-metallic and porous; it does not provide metal ions to react with acids. Its porosity can adsorb small amounts of liquid and provide breathability, which helped keep some foods from immediate spoilage but also caused absorption of lemon juice in our test

## **2. Why spinach, lemon, and tamarind behaved differently**

Each sample has different properties that explain specific reactions.

Spinach (leafy vegetable): Spinach contains chlorophyll, water, and delicate organic compounds (vitamins, enzymes). Chlorophyll degrades with oxidation and microbial spoilage, causing dulling or browning. In reactive utensils, metal ions and faster oxidation likely accelerated chlorophyll breakdown and produced unpleasant odours; in non-reactive vessels, oxidation was slower and spinach kept its green colour and mild smell longer.

Lemon juice with vinegar (acidic solution): High acidity makes lemon/vinegar the best indicator of metal reactivity. Acids attack metal surfaces and form soluble metal salts or coloured films (e.g., copper salts can be green-blue). The clay pot absorbed the liquid because of porosity, so visible liquid decreased—this is not a chemical preservation but physical adsorption. In copper and aluminum, acid caused colour changes and metallic odour quickly; in stainless steel and brass the acid remained stable.

Tamarind juice (acidic, complex organic mix): Tamarind contains organic acids and tannins which can complex with metal ions and darken on reaction. The tamarind samples darkened

fastest in reactive metals due to complex formation and oxidation; in non-reactive vessels the juice remained stable longer.

### **3. pH and nutrient considerations**

I measured pH changes (where possible), and the acidic samples showed pH drift in reactive metals. When metal ions dissolve into acidic media, they can either slightly change pH or catalyze oxidation reactions that degrade sensitive nutrients (for example, vitamin C). While my study used simple pH strips (qualitative), the observed pH changes matched visual and smell changes — greater chemical reaction correlated with greater pH instability and faster apparent nutrient degradation.

### **4. Physical properties that affected outcomes**

Porosity (clay): Clay's porous surface absorbs moisture and some liquid components; this free water for microbial growth but can also remove liquid sample (as seen with lemon), so it changes how we interpret "preservation."

#### **Thermal conductivity and thickness:**

Heavier/thicker utensils (clay, cast iron) hold heat longer; this affects cooling rate and can influence microbial growth and oxidation rates after cooking. Faster cooling (thin aluminum) could sometimes reduce thermal damage but did not prevent acid-metal reactions.

Surface finish and coating (non-stick): Non-stick surfaces prevent direct food-metal contact but the coating does not add nutrients. It remained visually neutral in my tests.

### **5. Comparison with hypothesis and prior expectations**

My results supported the hypothesis I stated in the introduction: non-reactive and traditional (clay, brass, stainless steel) performed better than reactive metals (copper, aluminum, cast iron) in preserving apparent freshness and preventing visible reactions. The behaviour of bronze (Kansa) and brass matched expectations — both performed well but showed mild changes over longer exposure, which fits their alloy nature.



## Reactivity of Utensil Materials with acidic foods

Reactivity level	Percentage %
Non Reactive ( Stainless steel, clay and brass)	60%
Mildly Reactive ( Non stick, Bronze)	20%
Highly Reactive ( Copper, Cast iron, Aluminium)	20%

## Risk Factors and Safety

- 1.Handle hot utensils carefully to avoid burns.
- 2.Do not overheat non-stick pans, as fumes may be harmful.
- 3.Avoid aluminum with acidic food.
- 4.Use clean utensils to prevent contamination.
- 5.Adult supervision is required while cooking.

## VI. CONCLUSION

Through this experiment, I have clearly understood that the type of utensil material we use in daily cooking has a strong influence on how well food retains its nutrients, freshness, and natural quality. My study on spinach, lemon juice, and tamarind juice in different utensils showed that some materials are safe and beneficial, while others can cause chemical reactions that spoil the food or reduce its nutrient value.

From my results, I found that stainless steel, clay pot, and brass utensils preserved the nutrients and freshness of all three samples very well. The spinach in these utensils stayed greener and smelled natural for a longer time. The lemon and tamarind juices also maintained their taste and acidity without any visible reaction. These materials are either non-reactive or mildly reactive, which makes them safe and healthy for cooking and storing food. Clay pots, in particular, allowed gentle cooking and absorbed excess moisture, which helped the food stay fresh longer.

On the other hand, copper, aluminum, and cast iron utensils reacted quickly with the food samples, especially with the acidic lemon and tamarind juices. These reactions caused color changes, metallic smell, and early spoilage. Such reactions indicate that reactive metals may release ions into the food, which can affect both the taste and the nutrient level. The non-stick utensil showed no major visible changes, but it also did not improve nutrient retention. It was found suitable only for short-time cooking, not for storage.

Overall, this experiment proved my hypothesis correct that natural and non-reactive materials help retain nutrients better than reactive ones. It also helped me realize that choosing the right cooking utensil is just as important as selecting healthy ingredients. Using traditional cookware such as clay, brass, and stainless steel is both eco-friendly and beneficial for maintaining the nutritional quality of our meals. This study made me more aware of the science behind everyday cooking and how small choices can make a big difference to health and food safety.

## **VII. REFERENCE**

<https://shopwithpraylady.com/blogs/news/which-cooking-utensil-material-is-best-for-health?srsltid=AfmBOoq4BmCaaqV2dplae4SwDn1l0mHnS2kWrAbv6TZT6HsTWX0xYkvDO>

### **Books and Articles**

Nutrient Retention Handbook: A comprehensive guide to nutrient retention in different water body types, including streams, rivers, lakes, and reservoirs.

Every Nutrient is Sacred: Developing a Nutrient Retention Paradigm to Aid Global Food Security\* by Steve Lapidge (2016): Discusses the importance of nutrient retention in ensuring global food security.

Nutrient Retention on ScienceDirect: Explores the preservation of vitamins and other nutrients in food during postharvest storage and cooking processes.

XSEED content book Grade 6 to 9

### **Research Papers**

Nutrient Transformation In Retention Detention Ponds Receiving Highway Runoff: Investigates nutrient removal efficiencies and transformation in retention/detention ponds.

Nutrient retention and loss during ecosystem succession: revisiting a classic paradigm: Examines the relationship between nutrient retention and biomass accumulation in terrestrial ecosystems.

### **Online Resources**

Grafiati: Offers lists of relevant articles, books, theses, and conference reports on nutrient retention and related topics.

RePEc: Provides access to research papers and articles on nutrient retention, including “Every nutrient is sacred: developing a nutrient retention paradigm to aid global food security”.

Studies

Effect of Non-Thermal Processing on Nutrient Retention in Dairy and Food Products: Explores the impact of non-thermal processing methods on nutrient retention