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Article

Effects of spices on rice spoilage

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SUMMARY

Spices have been used for centuries because they are thought to have antimicrobial properties that may delay food spoilage and prolong shelf life. Researchers have reported that chemical food preservatives like butylated hydroxy toluene (BHT) and butylated hydroxy anisole (BHA) can cause health hazards to humans, so we prefer organic food with natural preservatives. Rice is perishable once cooked. Hence, the purpose of our science project was to determine which types of commonly available spices would prevent or slow the growth of organisms in cooked rice. We hypothesized, based on the South Indian cultural practice of drinking "rasam" when sick to counteract infections, that some spices used in Indian cooking may have properties that enable them to fight infection and delay food spoilage by microorganisms. Hence for our experiment, we selected five spices in powder form and cooked white rice. We compared the outcome of adding spices to rice samples and measured spoilage rate by observing changes in color, texture and odor and detecting growth of mold on the rice samples and agar plates. According to the changes in smell and appearance of rice samples observed on days one through five, as well as growth detected on agar plates on day five, we can conclude that cinnamon was the most effective in delaying spoilage of cooked white rice, followed by cumin, pepper, garlic, and ginger. Although the tested spices cannot prevent spoilage of food, certain spices like cinnamon may have the ability to slow down the rate of food spoilage.

INTRODUCTION

Food preservation is the stopping or slowing down of food spoilage by preventing the growth of microorganisms while maintaining texture, flavor and nutritional value. Food undergoes spoilage due to physical (e.g., temperature, light, oxygen, water) and biological (e.g., microbial growth or enzymes) factors. Common microorganisms involved in food spoilage and responsible for causing food borne illness are bacteria, viruses, parasites, and fungi (e.g., yeasts and mold) (1). Spoiled food changes color, texture, and may have an unpleasant odor or undesirable taste. Many methods have been used to preserve food. Older methods like drying, salting, freezing, smoking and fermentation have been replaced by canning, pasteurization, irradiation, and the addition of preservatives. In addition to salt, sugar, alcohol, and vinegar, the commonly used chemical preservatives are benzoates, nitrites, sulfites, and antioxidants (2).

Spices have been used in a variety of cultures as a food preservative as well as to enhance the taste, smell, and appearance of food. Spices not only add flavor to food but are also thought to improve shelf life (3). In Hindu culture, masala (ground or powdered spices and herbs) as well as spice mixtures that incorporate garlic, cloves, cardamom, and cinnamon have been perceived to possess medicinal values (4). Spices and herbs have been tested and used to suppress bacteria growth and are used in countries with hot climates to delay food spoilage and maintain freshness (5). Plants owe their medicinal properties to their natural ability to synthesize numerous chemical compounds (6). Plants make phytochemicals or "plant chemicals" with antioxidant properties that protect them against insects, viruses, bacteria, and fungi, a few examples being flavonoids, phenolic acids, isoflavones, curcumin, isothiocyanates, and carotenoids (7). These same chemicals are thought to be beneficial to humans in protecting us from disease-causing organisms and other health problems (8). Our food spoils and loses palatability quickly without preservatives. While millions of people in underdeveloped countries suffer from lack of food and starvation, tons of food in developed countries goes to waste filling landfills, causing a high carbon footprint and a waste of money. Therefore, we need to find ways to preserve food. Popular artificial preservatives like butylated hydroxy toluene (BHT) and butylated hydroxy anisole (BHA) used to preserve flavor, color and odor of food can be harmful to our health, so by using natural preservatives like spices and easy preservation techniques, we can reduce food waste, increase food shelf life, and help feed people in countries with limited access to a safe, consistent food supply (9).

As microorganisms grow on food, they produce metabolic byproducts that can be used to measure spoilage. Conventional methods for detecting the growth of pathogens on food are based on culturing microorganisms on agar plates followed by standard biochemical identification using quantitative and qualitative analysis of their colony forming abilities. Measuring the diameter of a microbial colony as it spreads from a central point to cover the surface of the agar plate or observing and counting the colonies, measuring wet or dry mass, and measuring turbidity are some standard techniques used (10).

Sample	Spice odor			Bad odor		
	Day 1	Day 3	Day 5	Day 1	Day 3	Day 5
Control	-	-	-	-	-	++
Cinnamon	++++	++++	+++	-	-	-
Cumin	+++	++	+	-	+	++
Garlic	++++	+++	+	-	+	++
Pepper	+++	++	++	-	++	++
Ginger	+++	++	++	-	++	+++

Table 1: Tabular representation of odor. Comparison of spice smell to bad odor amongst rice samples on days one through five. - indicates no odor, + indicates presence of either spice smell or bad odor and multiple + symbols indicate increasing intensity of spice smell or bad odor.

In South India, "rasam" is a classic example of traditional soup eaten with rice, prepared using tamarind juice as a base, with the addition of turmeric, tomato, chili pepper, pepper, garlic, cumin, curry leaves, mustard, coriander, asafoetida, sea salt, and water. This soup is thought to have medicinal properties used to fight colds, throat infections, and fevers, which prompted us to use some of the spices for testing (11).

After reading multiple articles about spices and food preservation and our experience drinking "rasam" to fight infections, we hypothesized that Indian spices may have the ability to delay spoilage of cooked rice. Based on our observations and microscopic evidence, we found that cinnamon was the most effective in reducing microbial growth on rice. Our results warrant further study into the antimicrobial properties of household spices to determine their utility not only as coloring and flavoring agents but also in food packaging as a natural preservative to increase safety and shelf life.

RESULTS

We cooked Thai white Jasmine rice in a microwave and added one tablespoon of the cooked rice to each of the six small glass bowls while the rice was still warm and moist. We then observed the cooked rice samples after adding five different spices (cumin, ginger, garlic, cinnamon, and pepper) and compared them to a control rice sample kept at room temperature for five days at around 74 °F and estimated humidity of 60% **(Figure 1)**. We observed the bowls daily for changes in color, consistency, and smell and took pictures. On days one and two the experimental samples had a strong spice smell. By day three to five, the spice smell was replaced by a bad odor which gradually became worse except for the cinnamon sample, which retained some of the original cinnamon smell.

On day five, mold was obvious to the naked eye as a white, fluffy growth in the control sample and as a black, fluffy growth in the ginger sample. When observed under

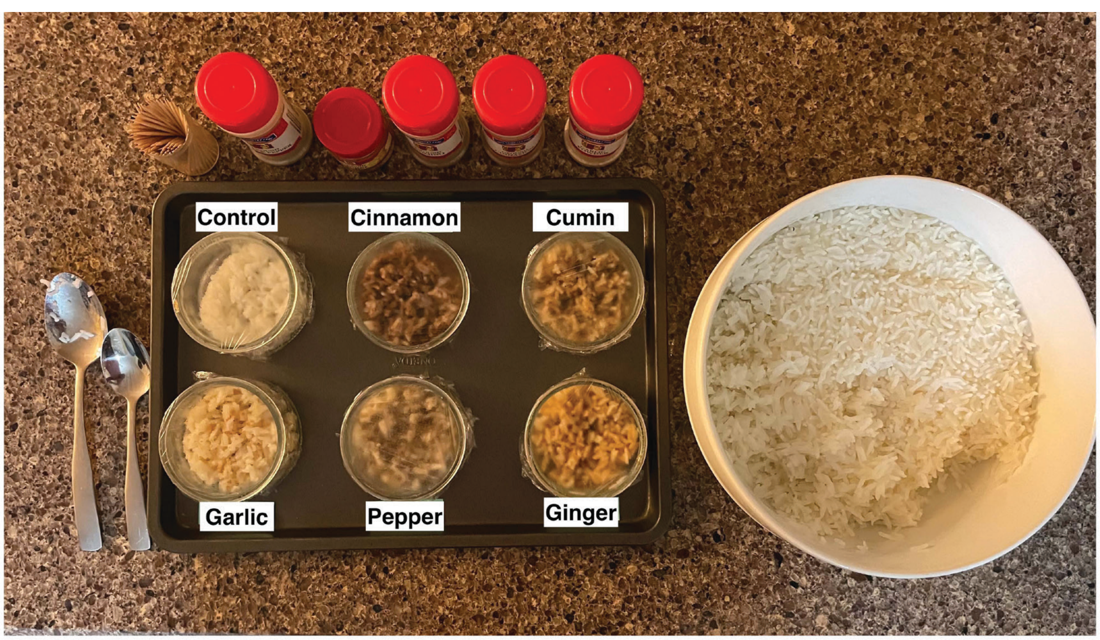

Figure 1: Images of materials used for the experiment. Clockwise from top: toothpicks, powdered spice bottles, cooked white jasmine rice, rice samples mixed with spices and dimensions of spoons used for measuring.

Figure 2: Observation of rice samples on days one through five. Mold is indicated with black arrows when magnified 800x. Fluffy white mold on the control sample and garlic sample, white thready mold on pepper sample and fluffy black mold on the ginger sample can be visualized.

a microscope, mold was also seen in rice samples mixed with garlic in the form of white fluff and pepper as white and stringy. Except for the rice mixed with cinnamon, which had not changed appearance since day one, all other rice samples looked degraded by day five **(Figure 2)**. Samples placed on agar plates on day five grew colonies – least on cinnamon and greatest on ginger **(Figure 3)**. We took pictures of one individual representative colony from each sample to demonstrate the color, form, elevation, and margin **(Figure 4)**.

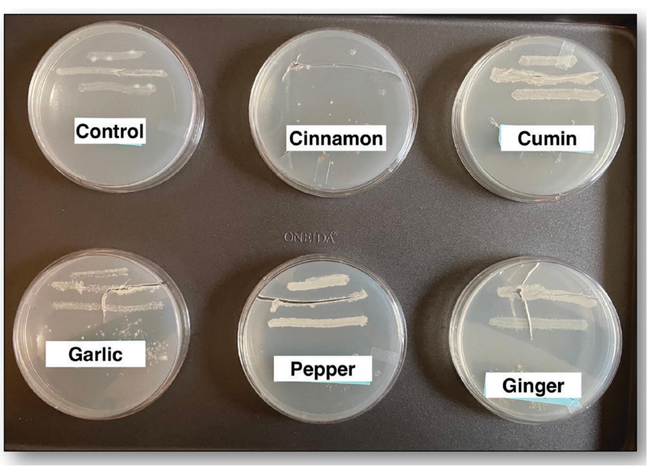

Figure 3: Observation of agar plates on day five for colony morphology. Pre-poured agar plates rubbed with mold from the rice samples using cotton swabs demonstrate dry, white, pinpoint colonies of differing size.

According to growth observed on the rice samples on days one through five and growth observed on agar plates on day five, we can conclude that cinnamon was the most effective in delaying food spoilage, followed by cumin, pepper, garlic, and ginger.

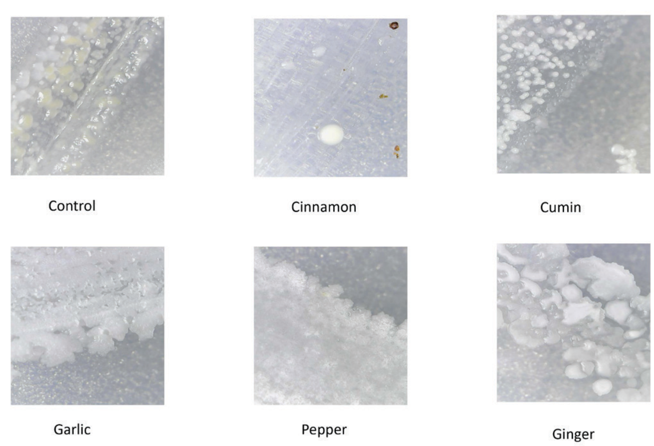

Figure 4: Microscopic images of agar plates after 48 hours with 800x magnification. Growth on respective rice samples observed for color, form, elevation, and margin with samples arranged clockwise.

DISCUSSION

Spices are natural ingredients that have been used mainly as flavoring and coloring agents and for their health attributes. Recently, there is growing evidence that phytochemicals in spices may have antimicrobial properties, shown to help food preservation (12). Rice is a cheap and popular food throughout the world, but it is known to perish quickly within hours if left outside once cooked, causing outbreaks of intestinal problems related to rapid growth of microorganisms (13). Since rice is a staple food in Asian countries, it was in our best interest as Asian Americans to determine a way to mitigate such a risk. Although there are many studies looking at the beneficial effects of spices on food preservation and safety, we could not find an experiment in the literature that used cooked rice as the food choice. Hence, the question we asked ourselves was whether spices could prevent or delay the spoilage of cooked white rice, and our hypothesis was that certain spices may have the ability to slow down rice spoilage.

Since our experiment was conducted solely at home, prior to organizing the actual project a pilot study was run comparing cooked white rice to rice mixed with chili powder to determine feasibility. After three days, it was noted that the rice mixed with chili powder was growing more mold than the control which, when observed under a microscope, was seen as white hair like structures with black spots **(Figure 5)**. We inferred that since the chili powder used for the study came from a jar that was open with an unknown shelf life, the spice powder jar may have been contaminated with organisms. This helped us determine that although dried spice powders are thought to have a relatively long shelf life, they may potentially grow mold depending on the way it is stored once opened. Hence, for the actual experiment brand new unopened spice bottles were used. Future studies exploring the presence or absence of preservatives within dried, powdered spices themselves and the shelf life of opened spice bottles may be beneficial in preventing contamination of daily food preparations.

At the conclusion of our experiment, according to growth seen on the rice samples and agar plates, rice mixed with cinnamon was the most effective in delaying food spoilage, followed by rice mixed with cumin, pepper, garlic, and ginger. Our experiment demonstrated that spices cannot prevent spoilage but do have the power to delay spoilage of cooked white rice. It will be interesting to further study the role of selected spices and spice combinations as natural preservatives for their potential use in rice and other food preparations to preserve and enhance shelf life.

MATERIALS AND METHODS

Rice was prepared by adding two cups of Thai white Jasmine rice to a wide-rim microwave safe bowl. The rice was washed and drained and four cups of water was added. The rice was then cooked in a microwave for 15 minutes.

For the pilot study, one tablespoon of the cooked white rice was added into two small glass bowls while the rice was still warm and moist. Half teaspoon of chili powder, from a bottle in the kitchen cabinet that was in use was added to one of the bowls and mixed well using a toothpick, keeping one untreated bowl as the control. Both bowls were covered with cling film and observed at room temperature around 74 °F and 60% estimated humidity.

For the actual study, rice was cooked as per the previous method and one tablespoon of the cooked rice was added into each of the six small glass bowls. Half teaspoon of spice powder (cumin, ginger, garlic, cinnamon, and pepper) from new, unopened spice bottles (Hill Country Fare brand without added preservatives as per label) was added into each bowl and mixed well using toothpicks, keeping one bowl as an untreated control. The bowls were covered with cling film, labeled, and left at room temperature, around 74 °F and 60% humidity. The bowls were observed daily for changes in color,

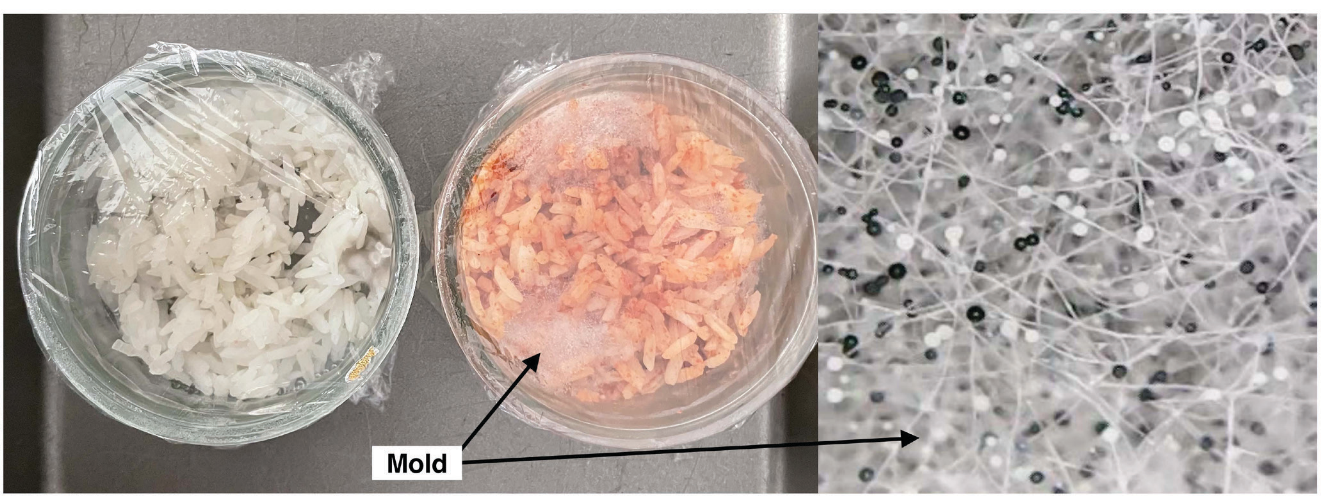

Figure 5: Pilot study comparing cooked white rice to rice mixed with chili powder. Black arrows show mold growth on the chili-rice sample, which when magnified 1000x shows white hair like structures with black dots.

consistency, and smell and pictures were taken. On day five when mold growth was seen, taking necessary precautions to prevent contamination of self and surrounding, samples were taken from each bowl using cotton tips and streaked onto prepoured nutrient agar plates (Es Evviva Science), and the rice bowls were discarded. Agar plates were sealed, labeled, and left for 48 hours at a room temperature of approximately 74 °F and 60% estimated humidity. The plates were observed visually and under a microscope. We used the Jiusion 8 LED portable microscope with the following specifications to view the samples on our Mac device: focus range from 1 mm to 90 mm, frame rate max 30 fs under 600 lux brightness and magnification ratios 40x to 1000x. We observed the colony morphology for color, form, elevation, and the magnified margin/border. We took pictures of one individual representative colony from each sample to demonstrate the form and margin. Plates were discarded appropriately, and the work area was cleaned.

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