Studying the effects of temperature and humidity on store-bought bread

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Apr 9, 2023

Abstract

This paper discusses the challenges faced by the bread industry and consumers due to bread spoilage and staling. Mold growth and staling are the main causes of bread spoilage, leading to economic losses for both the industry and consumers. The article discusses the factors that affect mold growth and bread staling, including temperature, humidity, moisture content, and storage. The aim of the experiment is to document the rate of staling and molding of bread under different conditions to determine the effect of temperature, humidity, and moisture content on bread. The paper concludes by highlighting the importance of natural extracts as an alternative to synthetic additives in the bread industry and the need for more effective measures against bread staling. The experiment shows that all the specimens become stale, and although none of the specimens had a change in color during the duration of the experiment, there are still concerns about the effectiveness of measures taken against staling compared to that against mold and implications of that in terms of the environment and food waste.

Introduction

Bread is a widely consumed staple food globally, and spoilage of bread is a major concern for the food industry and consumers alike, and industries are continuously striving to increase the shelf life of bread by delaying rates of molding and staling. Mold is a type of fungus that grows in warm, damp environments, and requires nutrients to thrive. Bread provides these nutrients, such as sugars and starches, which are broken down by the yeast during the fermentation process. This process releases moisture and carbon dioxide, which can create a warm and humid environment that promotes mold growth (Axel, Zannini, E., & Arendt, E. K. , 2017). Mold growth on bread is particularly common, with fungal spores being deposited from the bakery environment post-baking. Factors such as oxygen, temperature, pH, and water activity also play a crucial role in controlling the growth of undesirable fungi. Bread has a relatively high moisture content, making sliced, prepacked, and wrapped breads the most susceptible to mold spoilage (Axel, Zannini, E., & Arendt, E. K. , 2017). Wrapping freshly baked bread without any added preservatives allows suitable growth conditions for fungi in a humid atmosphere, reducing the shelf-life to just a few days at room temperature. Moldy bread is the main reason for bread being thrown away, causing economic losses for both the bakery industry and the consumer (Taglieri, Macaluso, M., Bianchi, A., et all , 2021). Bread staling occurs when there are chemical and physical changes in the crust and crumb during storage, which decreases consumer acceptance due to loss of freshness, crispiness, taste, and aroma (García-Hernández, Roldán-Cruz, C., Vernon-Carter, E. J., et all, 2023). The process may consist of the moisture transfer from crumb to crust during storage, causing the crust to absorb moisture from the interior crumb. Staling is a more complex and less understood phenomenon, hindered by the lack of understanding of its mechanism (Melini, & Melini, F., 2018). Factors affecting staling rate include storage temperature, moisture migration, crumb-crust redistribution of moisture, and moisture redistribution among components (Melini, & Melini, F., 2018).

As changes in temperature and humidity are common occurrences that happen in traditional storage of bread by consumers, this experiment will focus on documenting the rate of staling and molding of bread in a few environments such as room temperature, fridge, and freezer. The moisture content will be varied as well, and the goal of the experiment would be determining the effect of temperature, humidity, and moisture content on bread. This will be beneficial in exploring the different ways shelf life is accounted for in industry when making bread and how effective those measures are against staling versus molding. I hypothesize that all the bread pieces will get stale and hard, and the one kept at room temperature will grow mold and have a significant change of color, because mold grows better in higher temperatures (Axel, Zannini, E., & Arendt, E. K. , 2017).

Method

The purpose of this experiment is to show the effect of temperature and humidity on the freshness of store-bought bread. This observational record will test whether the common sentiments about the shelf-life of bread hold accurate for store-bought bread under various common environmental conditions. Bread is a staple food around the world and is seen as a convenient food with dishes such as sandwiches which are usually sold on the counter or are prepared in advance for people to take lunch to work or children to take lunch to school, so this study is crucial to be able to analyze the best ways to preserve bread. The experiment will be conducted over a period of five days for three specimens of bread. All the specimens are taken from the same packet of bread, so it can be assumed that factors such as type of bread, initial freshness, expiry date, ingredients of the bread, brand name, and previous storing conditions are all constant. A specimen will consist of a piece of bread on a tissue paper to prevent any contamination from the surface it is being kept on. The top of the bread will not be covered, to mimic the ordinary conditions of food being left out on the table or being sold on the counter. This will also ensure that humidity also has an effect on the bread and this will be tested when the top will be covered later on in the experiment. The primary changing variable will be the temperature and how that will affect the shelf life of the bread. Shelf life will be measured by a few things, including texture, color, and time before it goes stale. The first specimen was put in room temperature (74 F), the second specimen was put in the fridge with a temperature of 40 F, and the third specimen was put in the freezer with a temperature of 0 F. The position of the specimens was not changed throughout the duration of the experiment. At the end of the day everyday at 10 pm, I recorded visual evidence and anecdotal evidence with pictures. To test the texture of hard versus soft, I pressed a butter knife to a corner of the bread and classified the texture based on whether the knife formed a dent or not. To test the color, I will be judging visually. I will be taking notes on the difference in texture and use that to find the rate of which the bread is going stale. After 3 days, if all the specimens go stale, then I will change up the conditions of the experiment. Some changes I will make is that I will cover the top of the bread as well, and notice whether the rate of staleness is affected by the cover. I will also add moisture, to test whether it contributes to any microorganism growth.

For the data of each variable, texture will be measured in a scale of 1 to 10, with 1 being soft and springy and 10 being hard and brittle. A texture of 6 would signify that the bread was hard to the touch but was bendable without breakage. The edible range of texture is 1 to 3. The color will be measured on a scale of 0 to 2, with 0 being no change in color, 1 being slight change in color, and 2 being significant change in color.

Results

Description

This study has highlighted the effects of temperature and humidity on store-bought bread. Over a period of 5 days, different temperatures had various effects on the specimen and the rate they went stale. Staleness occurs when the moisture content of bread lowers and the bread dries out. The butter knife test showed the subtle and practical differences between the varying degrees of staleness. The colder environments had a lower humidity and temperature, so contributed to loss of moisture and stopped microbial growth, and they were hard in texture and the butter knife could not dent them. The hotter environment had higher temperatures and humidity but the bread still went stale due to exposure to air, so they were more flexible than the fridge specimen but were dried out due to humidity and were able to be dented by the butter knife. This can be clearly observed after Day 4 when the specimens were covered, they stayed softer for longer. This implies that the best way to keep bread fresh for the longest is keeping it covered in the fridge, because the specimen in the fridge had the slowest rate of change in texture and was able to get back to almost its original state upon adding moisture and covering.

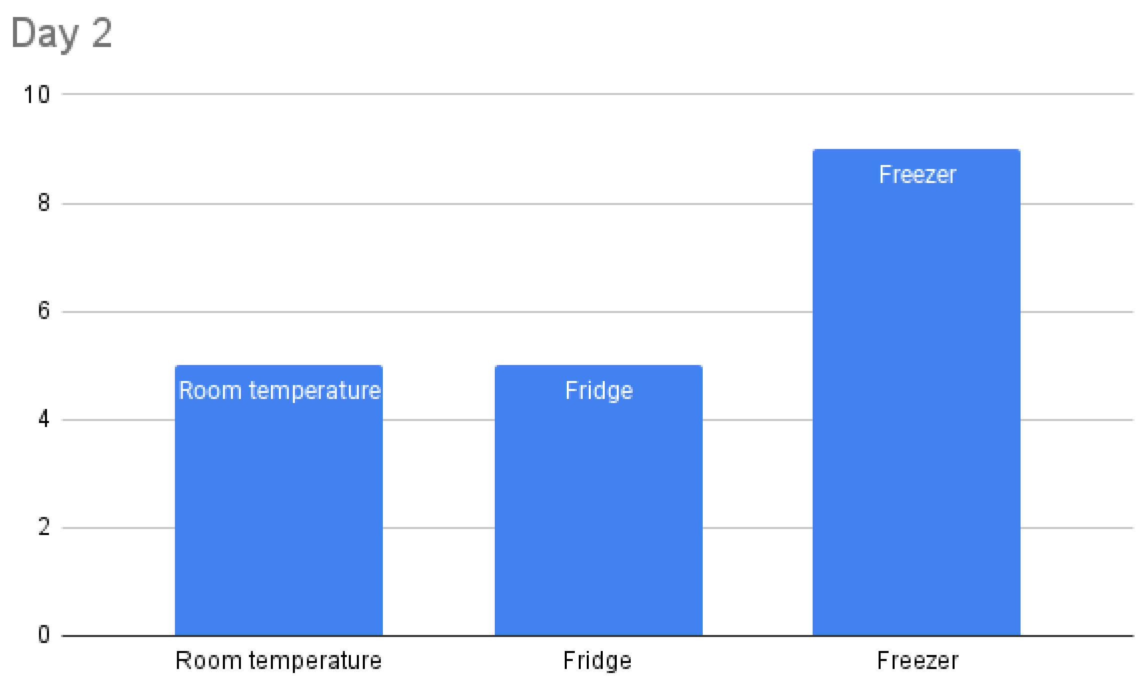

Chart: Scale of Texture on each specimen

The room temperature specimen and the freezer specimen got significantly harder in texture, but the fridge specimen stayed the same in texture. I then conducted the Butter Knife test again. Why was the texture constant in the fridge?

Specimen	*Performance when pressed by butter knife*
Room temperature	Created a permanent dent
Fridge	Created a permanent dent
Freezer	Did not create dent

Table: ***Summary of Results of Butter Knife test after Day 2.***

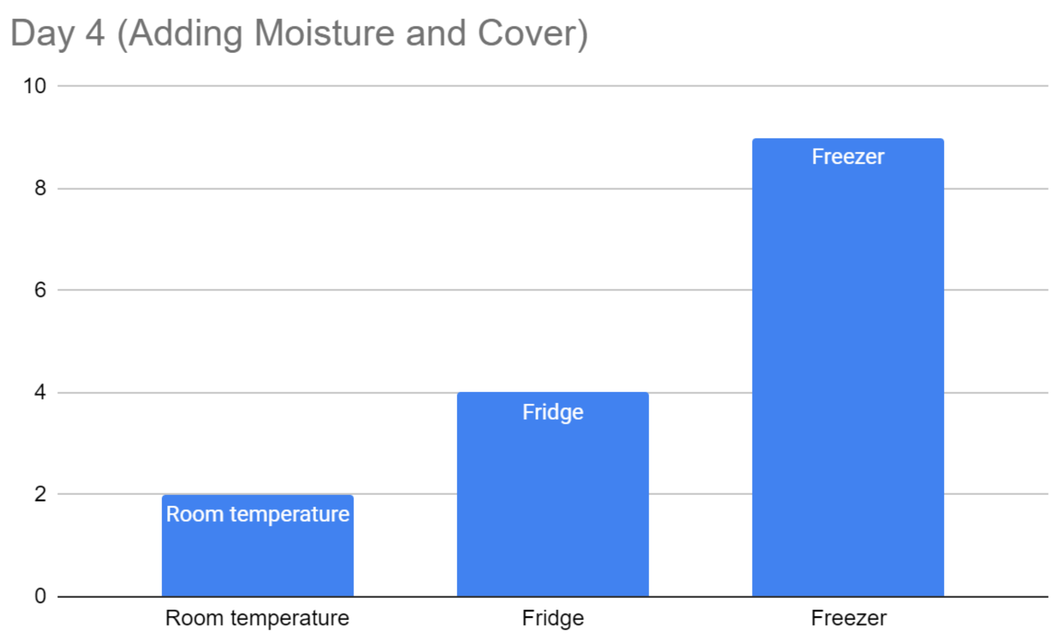

Chart: Scale of Texture on each specimen

The moisture caused a significant difference in texture in the room temperature and fridge specimen but nothing of note in the freezer specimen. The room temperature specimen got a type of squishy texture and the fridge specimen was back to a dry but bendable texture. I then repeated the Butter Knife test.

Specimen (the half which had extra moisture)	*Performance when pressed by butter knife*
Room temperature	Created permanent dent
Fridge	Created a temporary dent

Freezer	Did not create dent

Table: ***Summary of Results of Butter Knife test after Day 4.***

Unlike the hypothesis, none of the specimens grew mold or changed in color and the color always stayed at zero in the scale. This implies that store-bought bread has internal chemical properties that prevent it from microorganism growth. However, the staleness of the bread was not prevented, other than the partial recovery that was achieved through covering the specimen. The addition of moisture affected the texture of the bread as shown by the Butter Knife test, but did not cause mold growth.

Limitations

Different types of bread have different compositions, such as different moisture contents, which can affect the rate of staling. Even within the same type of bread, there may be variability in size, shape, and density, which can impact the rate of staling. In this experiment, only one type of bread was used, so the results are not universal for all types of bread. The experiment only involves a small sample size of bread, which is not a representative of all bread types or all conditions. A larger sample size could provide more accurate results. It is difficult to maintain consistent storage conditions for the bread in the fridge and freezer, as these conditions can be affected by the amount of food already in the fridge or freezer, as well as the frequency of opening and closing the doors. The fridge and freezer used belonged to multiple people, and their actions with the contents were unpredictable. The duration of the experiment was also a limitation, as a longer duration may have caused visible mold growth.

Discussion

Based on previous background, the initial hypothesis for the experiment was the appearance of bacterial growth on the room temperature specimen. The results show that this is not the case, as none of the specimens had a change in color during the duration of the experiment. This implies that there is a mechanism to prevent mold growth in store-bought bread. Chemical preservatives such as weak organic acids, like propionic and sorbic acid, are used to extend the shelf-life of bread by inhibiting the growth of undesired microorganisms (Melini, F., 2018). However, their usage is limited and regulated by the European Union (Takwa, Caleja, Barreira, J., et all, 2018). Potassium, sodium, or calcium salts of these acids are commonly used due to their higher solubility and ease of handling (Melini, & Melini, F., 2018). The addition of high concentrations of these preservatives can alter the sensory properties of bread and may lead to the development of fungal resistance. Ethanol can also be added to bread to increase shelf-life, and its addition on bread surface can also improve the effect of other preservatives (Melini, & Melini, F., 2018). The global population growth and consumer concerns have led the food industry to seek alternatives to synthetic additives in order to meet quality expectations while ensuring food safety (Takwa, Caleja, Barreira, J., et all, 2018). Although antimicrobials, antioxidants, and antibrowning agents are commonly used to preserve food, their potential toxicity and interactions with other chemicals have been a concern (Axel, Zannini, E., & Arendt, E. K. , 2017). Natural extracts, with their bioactive properties, have emerged as an alternative, and consumers are increasingly receptive to products made with natural ingredients to avoid unwanted effects of synthetic compounds (Takwa, Caleja, Barreira, J., et all, 2018).

Although the hypothesis regarding mold growth was incorrect, the speculation about all the specimens becoming stale was accurate, as shown in the data collected where all specimens had a texture higher than 3, and even though the fridge maintained a constant texture, it was still inedible due to its hardness proven by the Butter Knife test. The duration of the experiment was quite short, so this implies that the preventative measures by the industry taken against staling of bread are not as effective as that against mold. This brings up the issue of food waste as it is evident that storage methods have to be very precise and particular in order for bread to retain its freshness. Up to 30% of all bread produced is wasted due to staling (García-Hernández, Roldán-Cruz, C., Vernon-Carter, E. J., et all, 2023). This means that a large amount of resources, including water, energy, and agricultural land, are being used to produce bread that is never consumed. This has a significant impact on the environment, as the production of bread involves the use of natural resources and the release of greenhouse gasses. In addition to the environmental impact, bread waste also has economic implications. The cost of producing bread that is ultimately wasted represents a significant loss for producers, retailers, and consumers (García-Hernández, Roldán-Cruz, C., Vernon-Carter, E. J., et all, 2023). This waste also has a social impact, as many people around the world suffer from food insecurity and would benefit from access to nutritious food that would otherwise go to waste.

In terms of future research, there are several areas that could be explored to further understand the shelf life of bread. One area is the development of natural preservatives that can be used in place of chemical preservatives. Research could also focus on identifying different types of molds that commonly grow on bread and understanding the factors that contribute to their growth. This could lead to the development of more effective methods for preventing mold growth in bread, such as changes in the baking process or the addition of specific ingredients that can inhibit mold growth. Additionally, research could be conducted on the potential health effects of consuming bread with mold, and ways to minimize these risks. Finally, the preservatives should be researched more to find out whether they have any side effects or potential health or allergy risks.

References

Axel, Zannini, E., & Arendt, E. K. (2017). Mold spoilage of bread and its biopreservation: A review of current strategies for bread shelf life extension. *Critical Reviews in Food Science and Nutrition*, 57(16), 3528–3542. https://doi.org/10.1080/10408398.2016.1147417

García-Hernández, Roldán-Cruz, C., Vernon-Carter, E. J., & Alvarez-Ramirez, J. (2023). Stale bread waste recycling as ingredient for fresh oven-baked white bread: effects on dough viscoelasticity, bread molecular organization, texture, and starch digestibility. *Journal of the Science of Food and Agriculture.* https://doi.org/10.1002/jsfa.12442

Melini, & Melini, F. (2018). Strategies to Extend Bread and GF Bread Shelf-Life: From Sourdough to Antimicrobial Active Packaging and Nanotechnology. *Fermentation*, 4(1), 9–. https://doi.org/10.3390/fermentation4010009

Taglieri, Macaluso, M., Bianchi, A., Sanmartin, C., Quartacci, M. F., Zinnai, A., & Venturi, F. (2021). Overcoming bread quality decay concerns: main issues for bread shelf life as a function of biological leavening agents and different extra ingredients used in formulation. A review. *Journal of the Science of Food and Agriculture*, 101(5), 1732–1743. https://doi.org/10.1002/jsfa.10816

Takwa, Caleja, C., Barreira, J. C. M., Soković, M., Achour, L., Barros, L., & Ferreira, I. C. F. R. (2018). Arbutus unedo L. and Ocimum basilicum L. as sources of natural preservatives for food industry: A case study using loaf bread. *Food Science & Technology*, 88, 47–55. https://doi.org/10.1016/j.lwt.2017.09.041