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Edible Ideas: Experimental Test of Culinary Precisions

Does the age and associated pH of buttermilk influence the sensory properties of soda bread?

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Abstract

Culinary proverbs, tips and tricks, or old wives' tales lead to many variations in a recipe. In Molecular and Physical Gastronomy, the term "culinary precisions" is used to describe any piece of information that has something to do with the technical description of the dish, but does not belong to the definition (that is the minimum required to make the dish). The aim of this study was to test the culinary precision that "using aged-cultured buttermilk" (which should be more acidic than fresh buttermilk) improves the sensory properties of soda bread by promoting the chemical reactions between the acidic buttermilk and the alkaline sodium hydrogencarbonate. Three samples of cultured buttermilk (fresh, medium-aged, most-aged) were used to make three soda breads using the same recipe. The pH of each buttermilk sample was tested in triplicate and the values attained were within the acceptable range of 4.41 to 4.83 . Each of the three soda breads were assessed by a semi-trained panel (n = 15) for the sensory attributes of pore size, likeability, acidity and density and there were no significant differences found ($p \geq 0.05$) between the samples. It was concluded that while the culinary precision seemed true it was false.

Keywords

molecular and physical gastronomy, culinary precisions, soda bread, buttermilk

Introduction

In the 1980s two scientists, Hervé This and Nicholas Kurti, wanted to question the global methods of food preparation, looking for answers to questions such as "why do we cook as we

do?" and "why do we eat certain foods and avoid other perfectly edible ingredients?" (This, 2009). In 1988, they co-founded molecular and physical gastronomy (MPG), a sub-discipline of food science. At the foundation of MPG is the investigation of various culinary processes (Vega and Ubbink, 2008). Fooladi and Hopia (2013) noted that the investigation of "culinary precisions", that is proverbs, tips and tricks, or old wives tales is one of the pillars of MPG.

There are many claims and specifications about cooking that come from being passed down through generations, so much so that they have made their way into professional and domestic kitchens. Some are valid and achieve an intended result, while others are false, inaccurate, and should be debunked, as false culinary traditions can hinder a chef's culinary progression (Edwards-Stuart, 2012). The informal name for these claims and specifications is "culinary precisions". MPG provides a valuable framework for investigating these precisions and determining their accuracy through a scientific approach (Galanakis, 2021)

Examples of precisions include one which German chemist Justus von Liebig highlighted, "that meat juices contain nutritionally valuable compounds", and this later became interpreted wrongly on an international scale "roasting or pan searing at high temperatures to seal in the nutritionally valuable juices" (Leong, 2017). This is one of many examples of techniques that have been published in cookbooks, yet it is a culinary myth (Caporaso and Formisano, 2016).

The falsehood of some of these culinary claims has been revealed through MPG studies and results in questioning of the validity of the precisions we are familiar with. The study of precisions also has pedagogical relevance that could impact culinary teaching methods in the future (Caporaso, 2021). It is mentioned in the *20 Years of Testing Culinary Precisions* by This (2020) that "much remains to be done".

Another example of a culinary precision is "that the age of the buttermilk when used in a recipe for making soda bread has an influence on the sensory properties of the final product". A Master

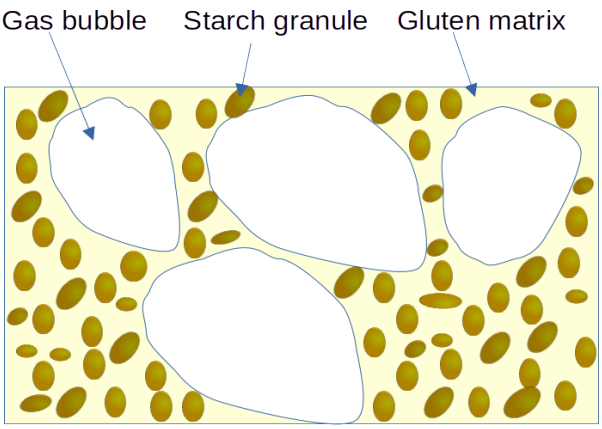

Figure 1. Carbon dioxide (CO_2) bubbles trapped in a gluten network in bread.

baker, stated in an interview conducted by *The Irish Times* that "if the buttermilk is not acidic enough, you won't get that big lift that we get in our soda bread" (Keena, 2018).

This statement is also endorsed by a number of other bakers, one stating that he believes that the buttermilk should be "sour and not fresh" as it will have a better reaction with the sodium hydrogencarbonate in the bread. When an alkaline substance, such as "sodium bicarbonate" (indeed sodium hydrogen-carbonate, $NaHCO_3$), is mixed with an ingredient such as buttermilk which is acidic, it is decomposed and generates carbon dioxide (CO_2) gas (Figure 1) and this helps to leaven the bread, making it more palatable (Brady, 2020).

In milk (pH 6.7 - 7.2), bacteria, such as *Lactobacilli* convert the disaccharide lactose (β-D-galactopyranosyl-(1→4)-D-glucose) into lactic acid (L, or a mixture of L and D depending of the bacteria strains), which is crucial in the formation of buttermilk. As Helmenstine (2019) explains "When buttermilk is made from butter, the milk sours naturally from bacteria present in the liquid", producing lactic acid. "This lactic acid lowers the pH of the milk, causing the casein proteins to precipitate". The buttermilk (pH 4.4 - 4.8) that is available to consumers and for large-scale production is cultured. Most modern buttermilk is cultured, meaning that beneficial bacteria have been added to it. It is different

from traditional buttermilk, which is rarely found in western countries today (Panoff, 2019; Mattox and Robertson, 2022).
The culinary precision that will be tested in this study is "that the more acidic the buttermilk, the better the leavening in the bread and therefore improved sensory properties are attained".

Materials and Methods

Ingredients

Plain flour (Odlums, Dublin, Ireland cream plain flour); table salt (Gem pack foods, Dublin, Ireland); sodium hydrogencarbonate (commonly known as "sodium bicarbonate" or "baking soda", Gem pack foods, Dublin, Ireland), cultured buttermilk (Arrabawn, Tipperary Ireland)
Each loaf contained the following ingredients and weight: 450 g plain flour, plus extra for dusting, 4.76 g sodium hydrogencarbonate, 4.76 g salt, 350 mL buttermilk (either freshest, medium-aged or most-aged). The buttermilk samples were aged in a Foster Xtra 1 Door 600L Cabinet Fridge (Buckinghamshire, England). The temperature was set to 4 °C and was calibrated weekly.

Recipe

The recipe to test this culinary precision was adapted from a soda bread recipe in *The MacNean Restaurant Cookbook* (Maguire, 2012). That recipe included rosemary and cranberries, however, these were omitted in this study as the focus of this test was the reaction between the buttermilk and the other typically recognised soda bread ingredients (flour, sodium bicarbonate and salt).

Method

The oven used (Retigo Oven, Model: E1011IZ Serial Number: 253421501, Rožnov pod Radhoštěm Czech Republic) was pre-heated to 220 °C (Maguire, 2012). The flour, sodium hydrogencarbonate and salt were sifted into a

Figure 2. Temperature reading of buttermilk after cooling to between 18 and 20 °C.

bowl. The temperature of each buttermilk sample was recorded with a calibrated Hygiplas Easytemp thermometer, model number: J242 (Wellingborough, England) before introducing the dry ingredients (Figure 2).
Three variations of the recipe were made by using one of the following buttermilk samples either fresh, medium, or most-aged (Table 1).

Table 1. Buttermilk samples for the pH and sensory testing.

Sample	**361**	**432**	**654**
Buttermilk	Freshest	Medium-aged	Most-aged
Age	22 days before the UDB	13 days past the UDB	18 days past the UDB

The buttermilk was added and a silicone spatula, was used to mix gently and quickly until a nice soft dough was achieved. A slight bit more buttermilk was added if necessary, so that the dough bound without being too wet. The dough was kneaded very lightly, by hand, on a lightly floured surface until a dough was formed and it could be shaped into a round that was approximately 15 cm in size. The kneading of

the dough took three to four minutes. It was placed on a baking sheet lined with parchment paper and a deep cross was cut with a dough scraper on the top to allow for an even rise and bake (Maguire, 2012) (Figure 3).

The dough was baked at 220 °C for 15 minutes. Then, after the temperature was reduced to 200 °C, baking went on for another 20–25 minutes, until the loaf was golden in colour and had a crusty texture. The bread was checked to see if it was properly cooked by tapping the base which should sound hollow. If not, the bread should be returned to the oven for another 5 minutes.

The cooked soda bread was then returned to a wire rack and left to cool for approximately 20 minutes. This process was repeated for each batch of soda bread (Figure 4).

After baking and cooling, the temperature of each sample was taken by inserting a calibrated thermometer. The Hygiplas Easytemp thermometer was inserted into the centre of each sample to ensure all loaves were at the same temperature (18–20 °C).

Figure 3. Uncooked soda bread before placing in the oven (361 = freshest buttermilk; 432 = medium-aged buttermilk; 654 = most-aged buttermilk).

The pH of the buttermilk samples was determined using an Orion Model 520A pH metre (AGB Scientific Ltd., Dublin, Ireland). The pH of each 30 mL sample was measured at 20 °C. Three replicates of each sample were prepared.

Figure 4. Baked soda bread after removal from the oven (361 = freshest buttermilk; 432 = medium-aged buttermilk; 654 = most-aged buttermilk).

Sensory testing methods

Fifteen semi-trained panellists worked in a single area under defined conditions of 18 – 20 °C and white light. Approximately 10 g of each of the three samples was placed in sample containers coded with three-digit random numbers which were 361 (freshest buttermilk) 432 (medium aged buttermilk) and 654 (most aged buttermilk). Samples were presented in a monadic sequential and randomized order to the panellists (ISO, 2017). Panellists were instructed to judge the pore size of the samples (1 = very large; 2 = large; 3 = just right; 4 = small; 5 = very small); indicate their acceptance of the overall flavour (1 = like very much; 2 = like slightly; 3 = neither like / dislike; 4 = dislike slightly; 5 = dislike very much), and acidity (1 = extremely acidic; 2 = very acidic; 3 = moderately acidic; 4 = slightly acidic; 5 = not acidic) and judge textural properties (1 = very light; 2 = slightly light; 3 = just right; 4 = slightly dense; 5 = very dense).

Results and Discussion

As can be seen in Table 1, sample 361 was the freshest buttermilk sample (22 days before the UBD), 432 was considered as medium-aged being almost 2 weeks past the UBD and 654 contained the most-aged buttermilk of all the samples at 18 days after the UBD. The results from the pH readings (Figure 5) show that sample 654 (most aged) is significantly different ($p \leq 0.05$) from the other 2 samples in terms of pH value. Sample 654 has an average pH reading of 4.73, while 361 and 432 have average pH reading of 4.48 and 4.43 respectively.

However, this result of pH 4.73 is within the range expected for cultured buttermilk which has a pH value falling in the range of 4.41 to 4.83 (FDA, 2004). The majority of the 15 sensory panellists (Figure 6) ranked all three samples as slightly acidic and not acidic.

Dong and Karbourne (2021) noted that the traditional leavening reaction between the sodium hydrogencarbonate and buttermilk is paramount to the quality of the bread. Therefore, panellists were asked to rank the pore size and lightness / density of the three bread samples.

In terms of the attributes of pore size, overall flavour and texture, Figure 6 indicates that the majority of panellists rated the pore size of all samples as small, the overall flavour of all samples as like slightly or neither like / dislike and mostly rated all samples as slightly dense

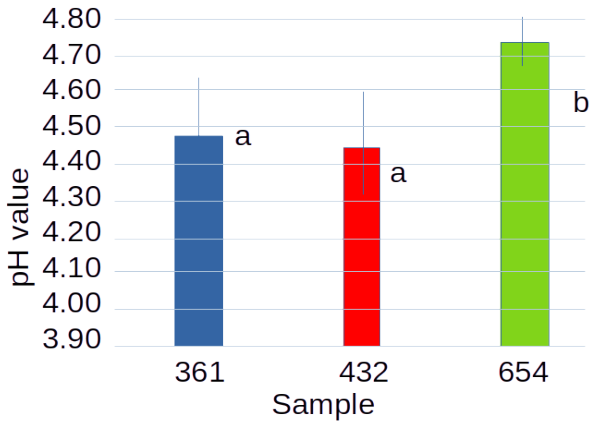

Figure 5.The pH values of the three buttermilk samples. Samples with different letters have significantly different means (p ≤ *0.05).*

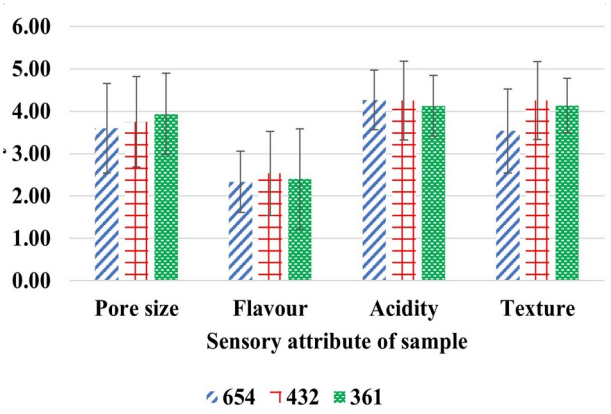

Figure 6. Mean sensory scores for pore size; flavour; acidity and texture. Each value is presented as a mean ± sd *(*n = *15).*

($p \geq 0.05$). The results suggest that the age of the buttermilk did not significantly enhance the rise or alter the crumb structure of the final product. These findings are consistent with previous research indicating that soda bread typically maintains a short and tight texture regardless of minor variations in ingredient freshness (McKenney, 2022).

Conclusion

The impact of age and associated pH of buttermilk on the sensory properties of soda bread was investigated. The pH analysis revealed that the acidity of the cultured buttermilk samples did not change significantly with age and that all samples were within the expected range. This was corroborated by the sensory analysis results which showed that there were no major differences between the samples in terms of acidity level, pore size, overall flavour likeability, and density of the bread. The outcome of this study is that the culinary precision of aged buttermilk enhancing the sensory properties of soda bread seems true but is false.

References

Brady DD. 2020. Exploring Some Fun Facts about Irish Soda Bread!. The Natural Push to Lifelong Health, https://drdavidbrady. com/exploring-some-fun-facts-about-irish-soda-bread, last access 2024-09-27.

Caporaso N, Formisano D. 2016. Developments, Applications and Trends of Molecular Gastronomy among Food Scientists and Innovative Chefs, *Food Reviews International,* 32(4), 417-435. https://doi.org/10.1080/ 87559129.2015.1094818.

Caporaso N. 2021. The impact of molecular gastronomy within the food science community, In *Gastronomy and Food Science,* Academic Press, London (UK), 1-18, https://doi.org/10.1016/B978-0-12-820057-5.00001-7.

Dong Y, Karboune S. 2021. A review of bread qualities and current strategies for bread bioprotection: Flavor, sensory, rheological, and textural attributes, *Comprehensive Reviews in Food Science and Food Safety,* 22(2), 1937-1981.

Edwards-Stuart R. 2012. Molecular Gastronomy in the UK, *Journal of Culinary Science & Technology*, 10(2), 97–105.

Fooladi E, Hopia A. 2013. Culinary precisions as a platform for interdisciplinary dialogue, *Flavour*, 2(1), 2-6.

FDA. 2004. Approximate pH of Foods and Food products. https://www.webpal.org/SAFE/aaarecovery/2_food_storage/Processing/lacf-phs.htm, last access 2024-09-27.

Galanakis CM. 2021. *Gastronomy and Food Science*, Academic Press, London (UK).

Helmenstine PM. 2019. What Is the Acidity or pH of Milk? https://www.thoughtco.com/what-is-the-ph-of-milk-603652, last access 2024-09-27.

ISO (International Organization for Standardization). 2017. *Sensory analyses. General guidance for the design of test rooms*, 8589:1998, 2(1),1-16.

Keena C. 2018. The rise and fall of bread baking as a craft industry, *The Irish Times.*

Leong N. 2017. Busting Cooking Myths: Searing Meat. https://nobyleong.com/category/cooking-science/, last access 2024-09-27.

Maguire N. 2012. *The MacNean Restaurant Cookbook*, Gill and Macmillan, Dublin (Ireland).

Mattox C, Robertson T. 2022. So What Is Buttermilk, Exactly, and How Do You Make It? https://www.countryliving.com/food-drinks/a30273717/what-is-buttermilk/, last access 2024-09-27.

McKenney S. 2022. Grandma's Irish Soda Bread. https://sallysbakingaddiction.com/grandmas-irish-soda-bread/, last access 2024-09-27.

Panoff L. 2019. Is Buttermilk Good for You? Benefits, Risks, and Substitutes. https://www.healthline.com/nutrition/buttermilk, last access 2024-09-27.

This H. 2009. Molecular Gastronomy, a Scientific Look at Cooking, *Accounts of Chemical Research*, 42(5), 575–583.

This H. 2020. 20 years of testing culinary precisions. https://www.europeanscientist.com/en/features/20-years-of-testing-culinary-precisions/, last access 2024-09-27.

Vega C, Ubbink J. (2008). Molecular gastronomy: a food fad or science supporting innovative cuisine?, *Trends in Food Science & Technology*, 19(7), 372-382.

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