Oxidation rates of apple slices under åã ^¦^}cÁ]PÁ&[}åãcã[}•

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Introduction:

oxygen, now present in plant cells, reacts with an enzyme called poly

implying that these acidic solutions denature the PPO enzyme. Thus, pH is \}[_}Ac[Aæ ^&cAc@^Aà¦[_}a}*A!æc^A[~Aæ]]|^•ÉAæ}åAc@ā•A^¢]^!ā{^}cA_ai|A•@[_A [-Å]PAGÁ . æ•Á&@[•^} Ac[Á!^'^&cÁæ} Aæ&ååå&Á•[|`cá[}ÉÁæÁ•[|`cá[}A[-Á]PÁĨÁc[Á!^'^&cÁ æÁ { ā|å|^Áæ&āåå&Á•[|ˇơi[}ÊÁæ}åÁæÁ•[|ˇơi[}Á[~Á]PĀF€ÁC[Á¦^'^&cÁæÁàæ•å&Á•[|ˇơi[}ĚÁ

Hypothesis and Prediction:

The hypothesis is that pH will have an impact on apple oxidation. The more acidic the solution that the apple is placed into, the less browning will be observed due to the pH of the solution leading to the denaturing of the enzyme PPO. Lemon juice, an acid with a pH of about 2, is commonly used to prevent apple oxidation, providing support for the hypothesis that an acidic solution will slow browning more than a basic solution. The solution of pH 2 acted as the acidic solution that should reå~&^ÁÚÚUÁæ&æçãc^Ác[Ác@^Á*¦^æc^•cÁ^¢c^}cÉÁc@^Á•[|~æi[}Á[-Á]PÁÎÁ¸æ•Á{ā|å|^Á acidic, and the pH 10 solution was the basic solution, which will most likely not slow apple oxidation. Bases like baking soda, for example, are not typical used to slow apple browning like lemon juice is. Suppose apple •|ā&^•Áæ¦^Á]|æ&^åÁā}c[Ác@¦^^Áåā ^!^}cÁ^¢]^!ā{^}cæ|Á&[}åācā[}•ÊÁæÁ•[|`cā[}Á [~Á]PÁGĒÁ]PÁÎĒÁæ}åÁ]PÁF€ĒÁæ}åÁc¸[Á&[}c¦[JÁ&[}åäċá[}•Á[~Áæá¦Áæ}åÁåPGUÈÁQ}Á that case, the apples placed into the acidic solution of pH 2 will exhibit a slower rate of oxidation over the course of 180 minutes by appearing less à:[, }ĒÁŒ]]|^•À]|æ&^åÀā}ÀæÀ•[|`cā[}À[-À]PÀĨÀ ,ā||Àæ|•[Àåā•]|æ^ÀæÀ•|[,^¦À[¢ādation rate than the basic pH 10 solution due to it being mildly acidic. The solution of pH 2 will denature the enzymes to the greatest extent, while pH ÎÁ . ā||Áå^}æcˇ¦^Ác@^ {Á•|ā*@c|^ĒÁæ}åÁ]PÁF€Á . ā||Á}[cÁà^Áæà|^Ác[Áå^}æcˇ¦^Ác@^Á enzymes. Finally, the browning rates of apples exposed to air will be higher than all the other apples placed in solutions because oxygen will be able to enter the damaged apple cells more easily. However, apples placed in water will display similar oxidation rater to the apples in pH 10, dH2O is neutral, but the water will help keep oxygen from entering the apple cells.

Materials and Methods:

OE祋}*|^Áæ]]|^Á,œ•Á&~cÁã}c[Á,~c^^}Á^ç^}Á•|ã&^•ĚÁV@^Áæ]]|^•Á,^!^Á then lightly scored with a fork to break down some cells. Three slices were]|æ&^åÅå}c[Á^æ&@Á[-Ác@^Á,ç^Á&~]•Á&[¦¦^•][}åå}*Ác[Á,ç^Á^¢]^¦å{^}cÁ&[}åå-

tions. For the four cups that contained the solution, enough of the condici[}q•Á¦^•]^&ciç^Á•[|~ci[}Á.æ•Áæåå^åÁc[Á&[ç^¦Ác@^Áæ]]|^Á•[i&^•ÈÁQ}ÁÔ[}c¦[JÁ FÉAc@!^^Aæ]]|^Á•|a&^•A,^!^A]|æ&^åAa}c[Aæ}A^{{}}c[Aæ}A^{{}}]A~[;AŒa;AÔ[}c;[|ÈAÔ[}c;[|A 2 had three apple slices and enough deionized water to cover the apples. \[\frac{\delta}{\delta} \frac{\delta}{\delt pH 10 solution to cover the apples. For each condition, about 5mL of solution was enough to cover the apples. In order to observe oxidation, the apples were kept in the cups and allowed to soak in their respective solutions ~[¦Á,ç^Á{ā}`c^•Áà^~[¦^Áà^ã}*Ácæ\^}Á[Áæ}åÁ]|æ&^åÁ[}c[Ác@^Á&`ccá}*Áà[æ¦åÁc[Á |^chai^A-[iAc,^}c^E,c^A{a}`c^•EhCE-c^iAc@aic^A{a}`c^•EhAAaa]a&c`i^A, æ•Acæ\^}A[-A repeated six times until 180 minutes had passed. The only exception to this process was at 0 minutes and 5 minutes. At 0 minutes, the apples had not ^^c4•[æ\^åÊ4¸@ā|^Áæc4ÍÁ{ā}`c^•ÊÁc@^Áæ]]|^•A@æåÁ•[æ\^åÁ~[¦Á,ç^Á{ā}`c^•ÈÁØānally, following the total 180 minutes, the pictures taken of the apples after €ĒÁÍĒÁH€ĒÁĴ€ĒÁJ€ĒÁFG€ĒÁFÍ€ĒÁæ}åÁFÌ€Á{ā}*c^•Á¸^¦^Áæ}æ|^:^åÁæ&&[¦åā}*Ác[Ác@^Á color palette shown below. The color of the apple was matched to the closest corresponding value, and the average color of the condition at every time point was calculated to examine the oxidation rate of apples (Figure 1).

> Figure 1.4 Ô[[[:Á •&æ|i] *Á]æ|^cc^Á ~[:Á [¢iåæci[] Á [-Á æ]]]^Á •|i&^•EÁ ŒÁ @i*@er number correlates to a deeper brown color and, thus, a higher rate of melanin production and apple oxidation. In other words, the darker the color, the more the apple slice has oxidized. This color palette, thus, was used in order to quantify apple browning data.

Written Results:

Initially, the average color value for all the apple slices across all conåäæi[}•Á¸æ•ÁFÈAŒ-c^¦ÁÍÁ{ä}~c^•ÊÁ@[¸^ç^¦ÊÁc@^Áåä ^¦^}cÁ&[}åäæi[}•Áåä•]|æ^^åÁ &[|[ˈlÁcæ|ˇ^Á[-ÁFĒŤÉÁ、@ā|^Ác@^ÁåPGUÉÁ]PÁŤÉÁæ}åÁ]PÁF€Á•[|ˇæ[}•Áåá•]|æ^^寿}Á average color value of 1.3. The pH 2 solution, however, stayed at a color value of 1, with no browning being observed. At the 30-minute mark, the &[}åici[}•Á@æåÁåi ^\^}ciæc^åÁ^ç^}Á~`;c@^!ÊÁ_ic@Ác@^ÁŒi;ÁÔ[}c;[]Áæ*æi}Á@æçi}*Á the highest color value of 3.3 and pH 2 having the lowest of 1.3. The dH2O åå•]|æ^^åÁæ}Áæç^¦æ*^Á&[|[¦Á[-ÁGÈÏЁÁc@^ÁÁ]PÁĨÁ•[|ˇcá[}Á[-ÁGÈHĒÁæ}åÁc@^Á]PÁF€Á •[|`ca:[}Á[~ÁFÈTĖNŒ-c^¦Á΀Á{ā}`c^•Ėhc@^Á•æ{^Ac¦^}åÁ[~Áà¦[¸}ā}*Á¸æ•Á[à•^¦ç^åÁ ¸āc@Ac@^AŒā¦AÔ[}c¦[|Aà^ā}*Ac@^A@ā*@^•cAæ}&Ac@^A]PAGAà^ā}*Ac@^A|[¸^•cÈAV@^A average color value of the dH2O, and pH 2 and pH 10 solutions all seem to have fallen, however. But what seems to be a reverse of browning can be explained by issues with the pictures that made the apples appear lighter c@æ}Ác@^^Á _ ^¦^ÈÁŒ-c^¦ÁJ€Á { â} `c^•ÊÁc@ [` * @ÊÁæ||Áæç^¦æ*^Á& [| [¦Áçæ| ` ^•Á@æåÁã}creased, with most notably the average color value of pH 2 increasing to 2. Ø[¦Ác@^Á¦^•cÁ[~Ác@^Á&[}åācā[}•ÊÁc@^ÁŒā¦ÁÔ[}c¦[|Á¸æ•ÁHÈÏĒÁåPGUÁæ}åÁ]PÁĨÁ¸æ•Á 3.0, and pH 10 was 2.3. At the 120-minute mark, the average color values [~Á]PÁGÁæ}åÁÎÁ¦^{ æã}^åÁc@^Á•æ{^KÁGÁæ}åÁHÊÁ¦^•]^&cāç^|^ÈÁŒ|JÁ[c@^;•Á@æç^Á ā}&!^æ•^åKÁc@^Áçæ|`^Á~[¦Ác@^ÁŒā¦ÁÔ[}c¦[|Áà^ā}*ÁIÈÏĒÁåPĠŪÁÔ[}c¦[|ÁHÈHĒÁæ}åÁ] PÁF€ÁHÈ€ĚÁŒ~c^¦ÁFÍ€Á { à} ˇc^•ÊÁ] PÁĨÁæ}åÁ] PÁF€Á@æåÁc@^Á•æ { ^Áæç^¦æ*^Á&[|[¦Á Çæ| ~^ A [~ÁHÈHÊÁ] @ā|^Á] PÁGÁ@æ•Áā}&!^æ•^åÁ•|ā*@c|^Ác[ÁGÈHÈÁV@^ÁŒā!ÁÔ[}c![|Á@æ•Á @}A@c^\@*^A&[|[\Ac@|`^A[-A[ETEA@A•i*}i,&@}cAi}&\^@•^EA@}aAc@^AaPGUA@}A@c-^\æ*^Áçæ|`^Á[~Á|ÈHĒÁæ}[c@^\Á•ā*}ā,&æ}chā}&\^æ•^ÈÁØā}æ||^ĒÁæ~c^\ÁFÌ€Á{ā}`c^•ĒÁ

solutions like lemon juice have been observed to slow melanin production in apples, and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis. As evi- $^{\} \$ and so that knowledge went into forming the hypothesis and so that knowledge went into forming the hypothesis and so that knowledge went into forming the hypothesis and so that knowledge went into forming the hypothesis and so that knowledge went into forming the hypothesis and so

Conclusion:

The data found in this experiment supported the hypothesis that c@^A [¢āåæcā[}Aæ}åĒAc@`•ĒA {^|æ}ā}Á]¦[å`&cā[}A[~Aæ]]|^•Aā•Aæ ^&c^åAà^Ac@^A pH of the solution the apple is in. It was previously predicted that a lower pH would lead to less melanin production or a slower oxidation rate because the acid would denature the enzyme polyphenol oxidase. The prediction was partly correct, with the apples in a pH 2 solution having c@^Á|[¸ ^•cÁæç^¦æ*^Á&[|[¦Áçæ|`^ÁæcÁc@^Á^}åÁ[-Ác@^ÁFÌ€Á {ã}`c^•ÊÁà`cÁ]₽ÁĨÁ had a higher average color value than the solution of pH 10. However, &[{]æ¦^āÅc[Á]PÁĠĒÁc@^Áæç^¦æ*^Á&[|[¦Áçæ|`^•Á[-Á]PÁĨÁæ}åÅ]PÁF€Á¸^¦^Á¦^|atively close. The scoring on the apples immersed in pH 10 solution also åååÅ}[ckæ]]^æ;Ac[hà^Aæ•Aå^^]Aæ•Ac@^A[c@^;•ÉA @å&@A {æ^A;^ç^æ|ÑAæ ^&c^åA melanin production because oxygen could not react with PPO. Only acidic solutions may be able to slow the rate of oxidation in comparison to mildly æ&åååå&Á • [|ˇːɑi[} •Á|ā\^Á]PÁÎÈÁ]PÁÎÀå•Á¦^|æɑiç^|^Á&|[•^Ác[Ác@^Á]PÁ[-ÁåPGUÈÁÏÉÁ possibly explaining the average color values being somewhat close to each other. Thus, the hypothesis is still supported due to similar melanin]¦[åˇ&æi[}Áà^Á]PÁÎĒÁ]PÁF€ĒÁæ}åÁåPGUÈÁÜ^*æ¦åá}*Ác@^Ác、[Á&[}c¦[|•ĒÁc@^Á apples were in neutral conditions in both cases. However, in the case of åPGUÊÁc@^Á, æc^¦Á { æ^Á@æç^Áæ&c^åÁæ•ÁæÁ‰à ` ^¦+Á-[¦Ác@^ÁÚÚUÁæ}åÁc@^Á[¢^gen by preventing the oxygen from entering some of the damaged apple cells. The apples in the air have no protection from oxygen, in other words.

Š[[\ia]* hædk@^h^¢]^la {^}ch.[[hæhà![æá^!h]^!•]^&ciç^thh]PhGth]Phfth and pH 10 solutions were chosen to have a spectrum of acidic to neutral دَالْمُعَةُ وَالْمُعُالِينَ اللهِ الْمُعَالَّمُ اللهِ الْمُعَالَّمُ اللهِ الْمُعَالَّمُ اللهِ الْمُعَالَّمُ اللهِ الْمُعَالَّمُ اللهِ اللهُ اللهِ اللهُ اللهِ اللهُ اللهِ اللهِ اللهُ اللهُ اللهُ اللهُ اللهُ اللهِ اللهُ اللهِ اللهُ اللهُ