

# OXIDATION'S EFFECT ON TEA

Presented By

**NEW YORK TEA SOCIETY**



# WHAT IS OXIDATION IN TEA

- Oxidation, in tea, refers to the enzymatic browning of tea leaves resulting from a series of chemical reactions set off when oxygen is introduced to enzymes in the leaves, producing flavor and aroma compounds in the finished teas.
- Skillful tea makers can manipulate the level of oxidation during processing to reach the desired flavor profile of the finished tea
- The chemical make up of *Camellia sinensis* is highly complex, with thousands of chemical compounds in each leaf.
- The complexity increases during processing when chemical compounds are broken down and reformed to produce new chemical compounds.
- In this tasting we will focus mainly on those chemicals involved in the oxidation process.



# What's Happening Inside *PART 1*



- **Amino Acid**
  - Provides sweetness in the flavor profile of tea
  - Theanine is the main amino acid in tea
    - It is more abundant in early spring harvest
    - L-Theanine combines with caffeine to give the “mindful alertness’ effect
      - L-theanine is only found in tea and some kinds of mushrooms
- **Polyphenols**
  - Provide astringency and bitterness to the flavor profile of tea
  - Produced as a defense against insects
  - Sunlight converts amino acids into polyphenols
    - Less sunlight while growing = less bitterness
  - Lower concentration in early harvest season
    - Balanced by a lot of amino acids for a taste that is mellow and rich
  - Higher concentration in later harvest
    - With fewer amino acids, resulting in flavor that is more bitter and astringent
- **Flavanoids** is the most important polyphenol
  - **Flavanols** is the most known flavanoid
    - Aka Tannins, Catechins
    - Oxidation of flavanols reduces catechin content in flavanol ,converting them into
      - **Theaflavins** 10%
        - Responsible for dark color in oxidized teas
        - Contain astringency without bitterness
      - **Thearubigins** 90%
        - Responsible for dark colors
        - Contain astringency without bitterness
        - Longer oxidation= less bitterness

# What's Happening Inside *PART 2*



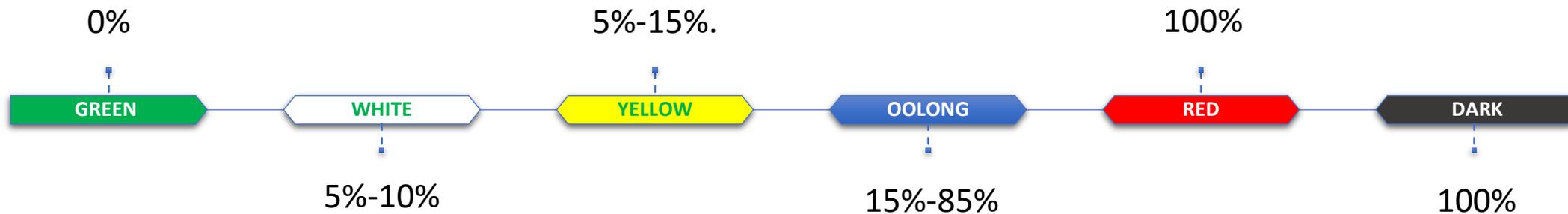
- **Pigments**
  - Responsible for the tea leaves color
  - Responsible for absorbing light for photosynthesis
  - Condense during withering and oxidation, causing them to become darker
  - Two Main types in Tea Leaves
    - **Chlorophylls**
      - During oxidation, green chlorophylls degrade and become
        - **Pheophytins**, black pigments responsible for oxidized tea's dark color
    - **Carotenoids**
      - Two Main Types
        - **Orange Carotenes**
          - Degrade during processing into many derivative compounds providing flavor
          - **Damascenone** - provides sweetness
        - **Yellow Xanthophylls**
          - Contribute mostly to color
- **Volatiles**
  - Volatile substances enter the air from tea leaves or tea liquor, and they reach our olfactory system as a vapor.
  - Responsible for flavor and aroma
  - Tea's aroma complex is made up of thousands of volatile flavor and aroma compounds that exist in trace amounts.
  - Many of these compounds do not exist in fresh tea leaves, they come from other substances during processing
  - The flavor and aroma of each finished tea depends on a wide variety of combinations of compounds
    - Linalool And Linalool Oxide - Floral Notes And Sweetness
    - Geraniol And Phenylacetaldehyde - Floral Aromas
    - Nerolidol, Benzaldehyde, Methyl Salicylate, And Phenyl Ethanol - Fruity Flavors
    - Trans-2-hexenal, N-hexanal, Cis-3-hexenol, And B-ionone - Tea's Fresh Flavor
- **Carbohydrates**
  - Created in mature leaves as a form of energy
  - Sent to the roots for storage during dormant winter months
  - Retrieved to power the growth of new buds in spring making the new growth naturally sweet
  - Higher levels found in mature leaves but are balanced by higher levels of bitter polyphenols

# What's Happening Inside *PART 3*



- **Enzymes**
  - **Peroxidase**
  - **Polyphenol Oxidase**
    - Responsible for the enzymatic browning of tea leaves
    - Can be denatured or deactivated by
      - Applying heat - 150 degrees Fahrenheit.
      - Depriving of moisture
- **Methylxanthines**
  - Natural pesticide
  - Add bitterness to the flavor profile of tea
  - Bud has the highest concentration. Each lower leaf has less concentration.
  - Three types found in tea
    - Theobromine
    - Theophylline
    - Caffeine
  - The level of methylxanthines in tea depends
    - Cultivar
    - Climate
    - Age Of The Leaves
    - Propagation Method (Seed Vs. Cutting)
- **Minerals**
  - 28 mineral elements have been found in tea leaves
  - High amounts of
    - Fluorine
    - Manganese
    - Arsenic
    - Nickel
    - Selenium
    - Iodine
    - Aluminum
    - Potassium

# Oxidation Levels in Tea Categories



All tea is produced from the camelia sinensis plant. How the tea leaf is processed creates variations in the oxidation level of the finished tea. The principle determining factor which separate teas into different categories is its level of oxidation.

- Green tea is not oxidized
- White tea is 5-15% oxidized
- Yellow tea is 5-15% oxidized
- Oolong tea is 10-85% oxidized
- Red tea is 100% oxidized
- Dark tea is 100% oxidized

# PASSIVE VS ACTIVE OXIDATION

- The moment the tea leaf is picked the enzymes in the leaf begin to oxidize it.
- **Passive Oxidation** is when the leaves naturally oxidize while drying, as in white tea production
- When a higher level of oxidation is required, tea makers bruise the leaves to release enzymes through-out the leaf, resulting in a higher level of oxidization.
- This process of intentionally increasing oxidation is known as **Active Oxidization**.

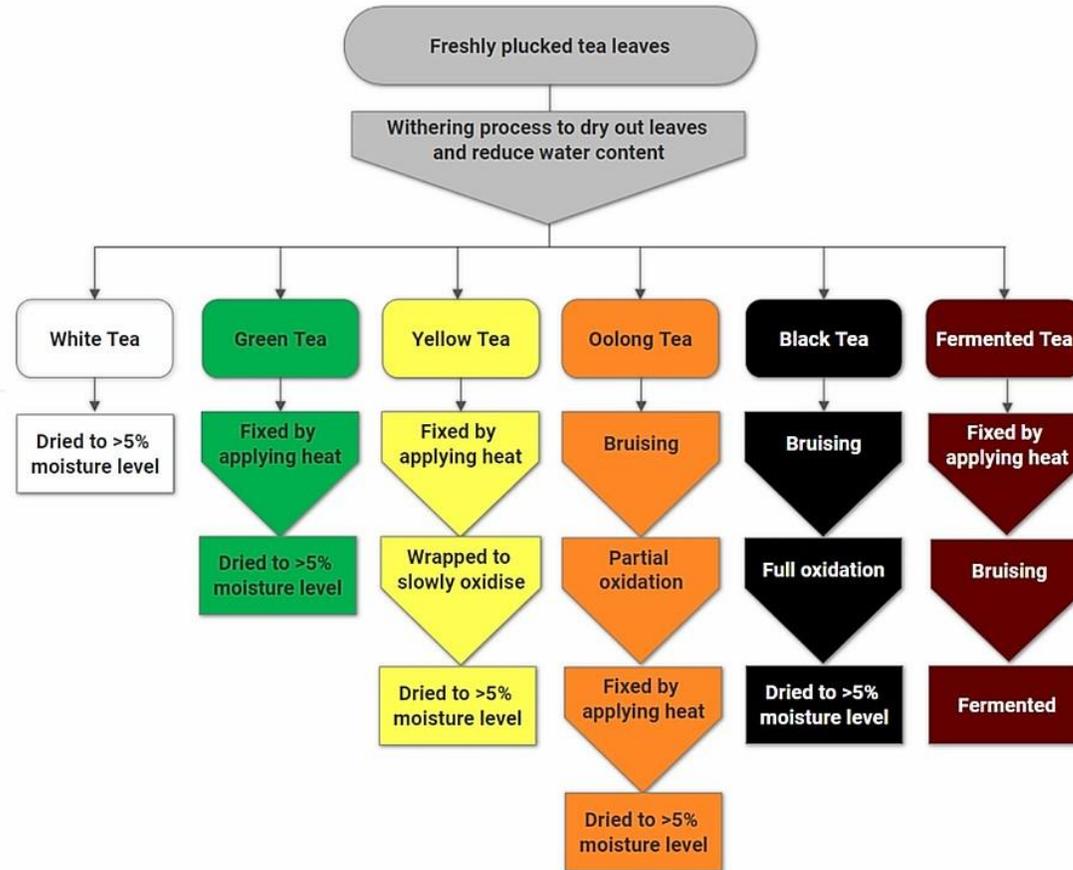


# 'FIXING' THE TEA



- Oxidation begins as soon as the tea leaves are picked.
- The rate of oxidation can be accelerated by using different production methods such as rolling or tumbling to release more enzyme (polyphenol oxidase) into the leaves
- Once the tea is oxidized to the appropriate level, the leaves are then 'fixed' by exposing them to heat.
- 'Fixing' halts the oxidation process and prevents the tea from darkening further.
- Fixing tea can be achieved by;
  - Pan-Firing (*ie., lu'an*)
  - Steaming (*ie., sencha*)
  - Baking (*ie., dancong*)
  - Sun-Drying (*ie., bai mudan*)
- The amount of time the tea leaves are oxidized before being fixed will be an important determining factor on what category of tea is produce.
- Oxidation level will have a huge impact on the teas;
  - Color
  - Aroma
  - Flavor
  - Body

## HOW DIFFERENT TEAS ARE MADE



# KILL GREEN

- Green tea has little to no oxidization.
- In order to achieve this, all the enzymes in the leaf must be denatured and rendered inert.
- This is achieved with a processing method called **Kill Green**.
- The wilted leaves are applied high heat, literally "killing" the enzymes and effectively halting oxidation. This can be achieved by;
  - Pan-Frying (*Chinese Teas*)
  - Steaming (*Japanese Teas*)
- The kill green stage allows the tea to retain its bright green color and original taste after processing and drying.
- Technically, green tea does undergo a small amount of oxidation, since oxidation begins as soon as the leaf is picked.





## How Oxidation Effects Green Tea

- Green teas are unoxidized
- They have little to no oxidation
- They undergo 'kill green' to halt oxidation as soon as possible after a small amount of wilting, which removes water content from the fresh leaves
  - Chinese green teas are typically pan-fired
  - Japanese teas are typically steamed.
- The polyphenol content of green teas is like that of the fresh leaves
- Green tea leaves are typically bright green, reflecting the original color of tea leaves after harvest.
- The brewed tea liquid is a light yellow or yellow-green color

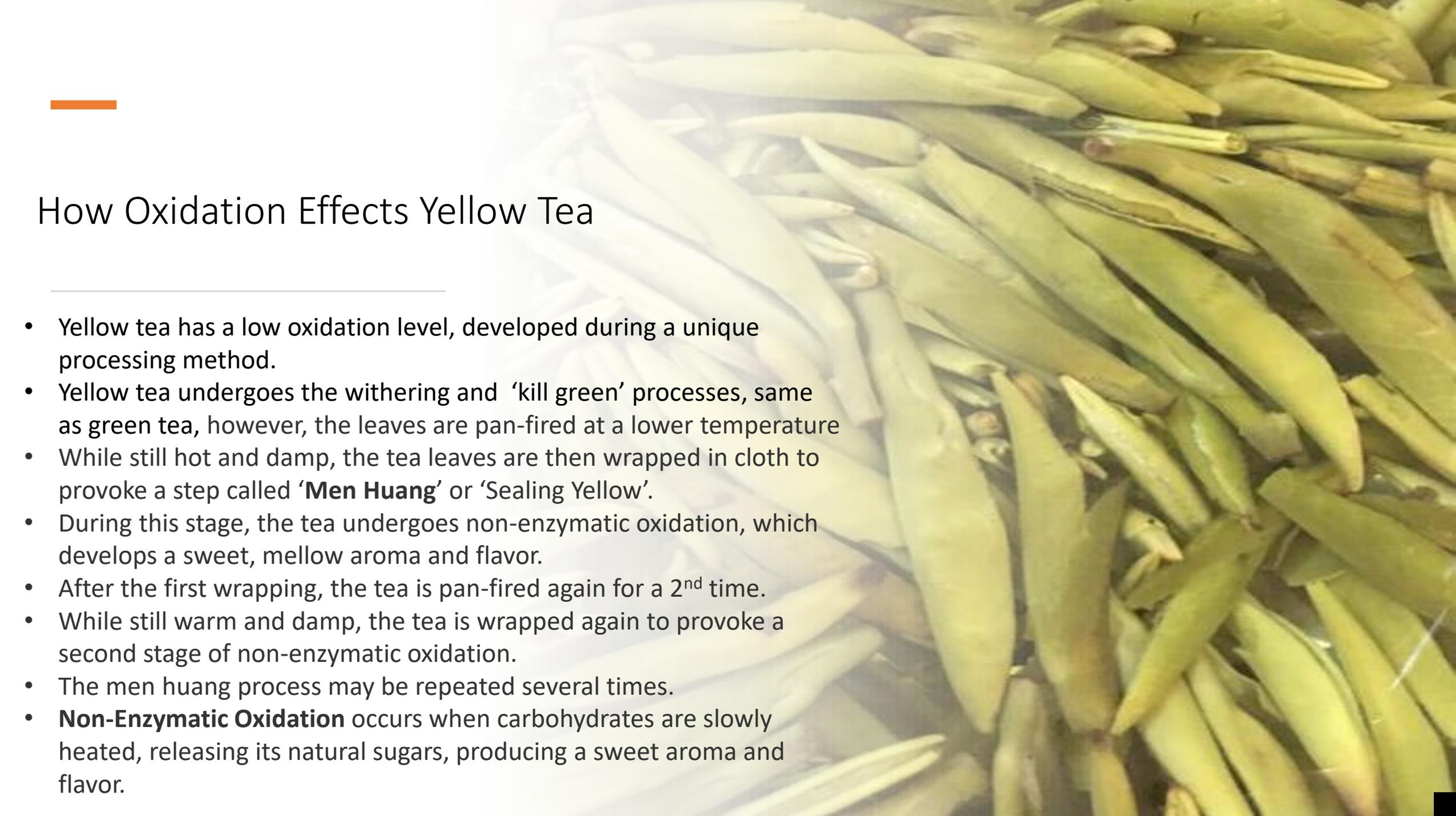


## How Oxidation Effects White Tea

---

- Traditionally, white tea is sun-dried immediately after picking
- Modern processing of white tea uses indoor air-drying where tea makers can better control the temperature and humidity parameters
- Although white teas do not undergo active oxidation processes of black or oolong teas, they do undergo passive oxidization during the drying process.
- The result, is a small amount of oxidation, varying between 5% - 15%

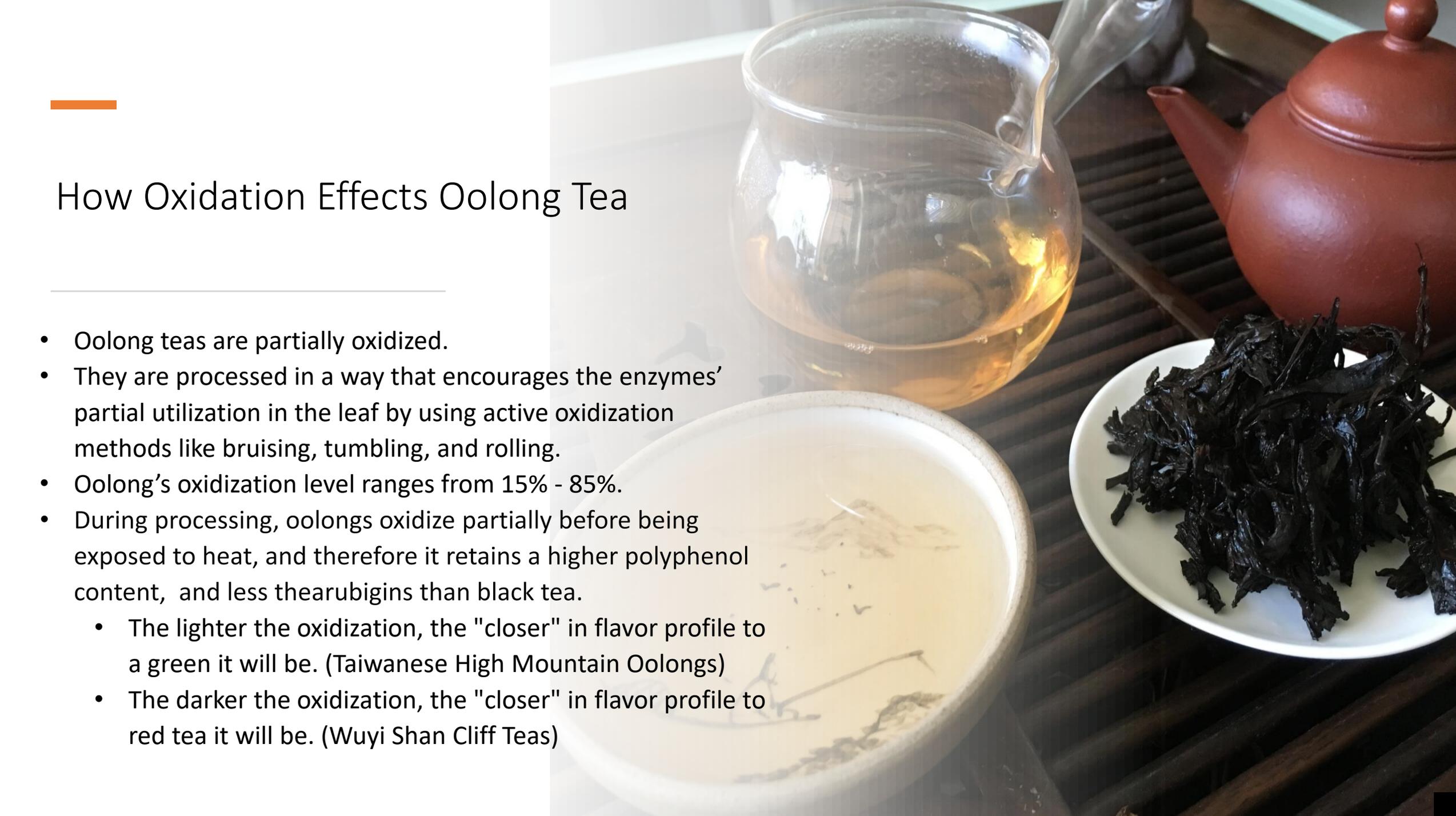




---

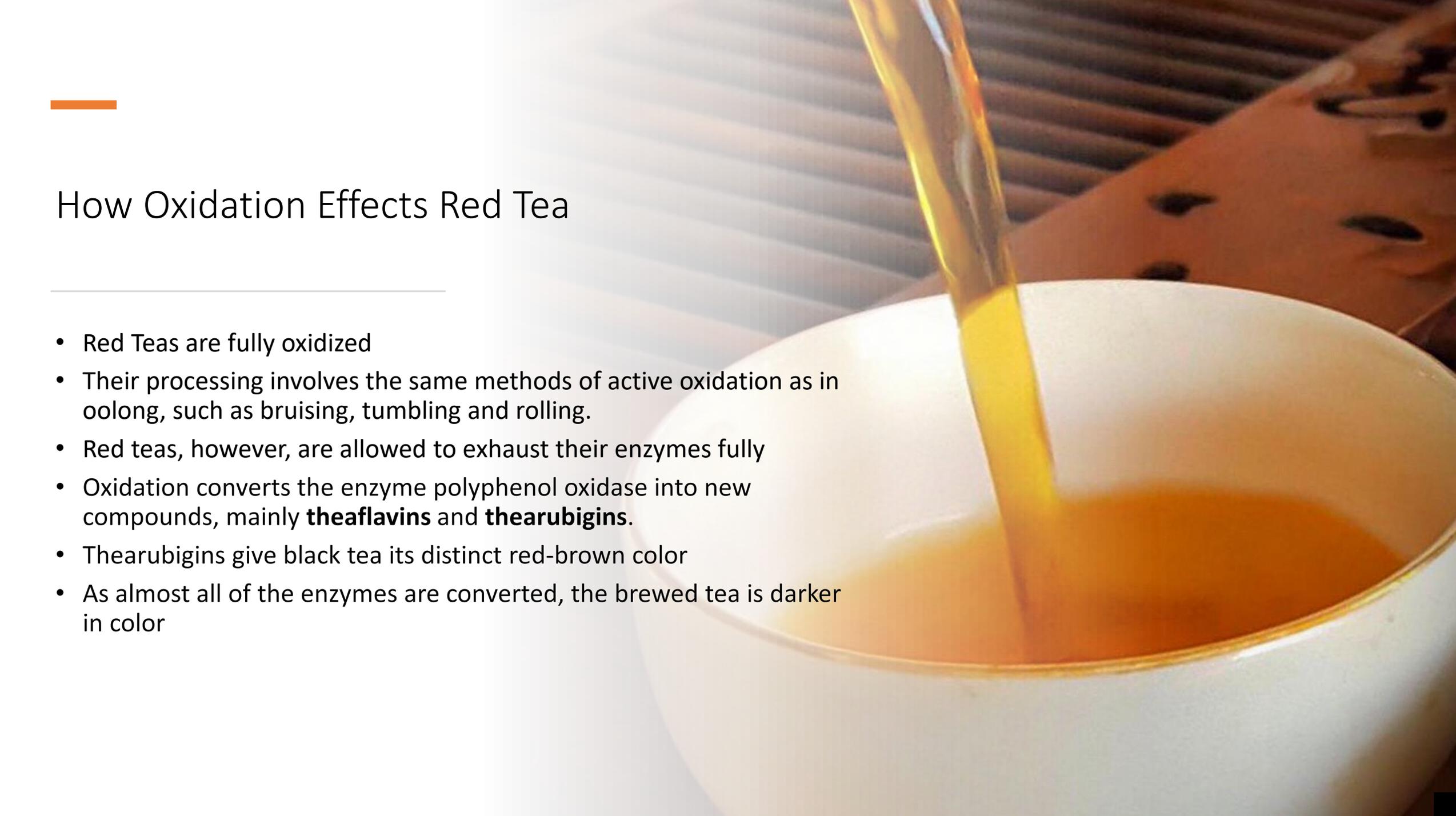
## How Oxidation Effects Yellow Tea

- Yellow tea has a low oxidation level, developed during a unique processing method.
- Yellow tea undergoes the withering and ‘kill green’ processes, same as green tea, however, the leaves are pan-fired at a lower temperature
- While still hot and damp, the tea leaves are then wrapped in cloth to provoke a step called ‘**Men Huang**’ or ‘Sealing Yellow’.
- During this stage, the tea undergoes non-enzymatic oxidation, which develops a sweet, mellow aroma and flavor.
- After the first wrapping, the tea is pan-fired again for a 2<sup>nd</sup> time.
- While still warm and damp, the tea is wrapped again to provoke a second stage of non-enzymatic oxidation.
- The men huang process may be repeated several times.
- **Non-Enzymatic Oxidation** occurs when carbohydrates are slowly heated, releasing its natural sugars, producing a sweet aroma and flavor.



## How Oxidation Effects Oolong Tea

- Oolong teas are partially oxidized.
- They are processed in a way that encourages the enzymes' partial utilization in the leaf by using active oxidation methods like bruising, tumbling, and rolling.
- Oolong's oxidization level ranges from 15% - 85%.
- During processing, oolongs oxidize partially before being exposed to heat, and therefore it retains a higher polyphenol content, and less thearubigins than black tea.
  - The lighter the oxidization, the "closer" in flavor profile to a green it will be. (Taiwanese High Mountain Oolongs)
  - The darker the oxidization, the "closer" in flavor profile to red tea it will be. (Wuyi Shan Cliff Teas)



## How Oxidation Effects Red Tea

---

- Red Teas are fully oxidized
- Their processing involves the same methods of active oxidation as in oolong, such as bruising, tumbling and rolling.
- Red teas, however, are allowed to exhaust their enzymes fully
- Oxidation converts the enzyme polyphenol oxidase into new compounds, mainly **theaflavins** and **thearubigins**.
- Thearubigins give black tea its distinct red-brown color
- As almost all of the enzymes are converted, the brewed tea is darker in color



## How Oxidation Effects Dark Tea

- Dark Teas aka Hei Cha is tea which has undergone post-fermentation
- Oxidation is not the same as fermentation.
- Oxidization is chemical breakdown by oxygen.
- Fermentation is the chemical breakdown by microbes.
- Dark Teas are fully oxidized teas which then undergo a production method called **Wo Dui**.
  - Wo Dui is a process in which fully oxidized tea leaves are moistened and covered for a period of time, under a controlled environment, exposing the leaves to naturally rising temperatures and humidity
- These conditions encourage microbial changes within the tea leaves to take place, changing the flavor, aroma and color of the brewed tea.
- Although Pu'er is sometimes classified as Dark Tea, it creates controversial discourse for the following reasons
  - Shou Pu'er is made with maocha, which is technically, a green tea and not an oxidized tea
  - Sheng Pu'er is made with maocha and does not undergo the wo dui process, instead it is allowed to age for a long period of time, creating the microbial changes naturally.

# DARK TEA VARIETIES



- Most teas are oxidized not fermented; however fermented teas do exist as Hei Cha aka Dark Tea
  - China
    - Hunan Heicha 湖南 黑茶
      - Fu Zhuan 茯砖 “Fu Brick”
      - Hua Juan Cha 花卷茶
        - Qian Liang Cha 千两茶 “Thousand Tael Tea”
        - Bai Liang Cha 百两茶 “Hundred Tael Tea”
        - Shi Liang Cha 十两茶 “Ten Tael Tea”
      - Hua Zhuan 花砖 “Flower Brick”
      - Hei Zhuan 黑砖 “Dark Brick”
      - Xiang Jian 湘尖 “Hunan Tips”
        - Tian Jian 天尖 “Heaven Tips”
        - Gong Jian 贡尖 “Tribute Tips”
        - Sheng Jian 生尖 “Raw Tips”
      - Qu Jiangbo Pian 渠江薄片 “Qu Jiang Thin Slice” (coin-shaped tea)
    - Sichuan Heicha 四川 黑茶
      - Nan Lu Bian Cha 南路边茶 “South Border Tea”
      - Xi Lu Bian Cha 西路边茶 “West Border Tea”
      - Kang Zhuan 康砖 “Kang Brick” literally “Peaceful Brick”
    - Anhui Heicha 安徽 黑茶
      - Lu An Cha 六安茶
    - Hubei Heicha 湖北 黑茶
      - Qing Zhuan 青砖 “Green Brick”
    - Guangxi Heicha 广西 黑茶
      - Liu Bao Cha 六堡茶
    - Yunnan Heicha 云南 黑茶
      - Puer 普洱
        - Sheng Puer 生普洱 (not considered fermented until intentionally fermented)
        - Shu Puer 熟普洱
  - Japan
    - Awabancha 阿波番茶
    - Goishicha 碁石茶
  - Vietnam
    - Phổ Nhĩ