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# Impact of Withering time duration on some Biochemical Properties and Sensory Quality Attributes of Black Tea

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**ABSTRACT: Withering as first stage in black tea manufacturing is very important for producing black tea with high quality. During the tea green leaf withering, reduction in moisture content of the tea leaves is accompanied by occurrence of biochemical interactions that play an important role in black tea quality. Withering stage includes two parts as physical and biochemical withering. Withering time duration play an important role in biochemical interactions. In the present study, impact of withering time on the quality of black tea was examined based on environmental conditions and green tea quality through colorimetriy experiments and sensory quality evaluation by tea tasters. Also tea water extract was determined. A laboratory scale trough was used for withering operation. Temperature of blown air was 27°C and air flow rate was adjusted in 6.3 $m^3$/min per 1 kg tea green leaf. Withering time was considered with five levels in three replications. Results related to determination of tea water extract showed a rising trend in water extract during withering. Withering time hadn't a significant effect on theaflavin (TF) content and tea liquor brightness. But thearubigin (TR) content and tea liquor color were changed significantly during withering, so that the withered leaves in 16 hours had highest content of thearubigin. Sensory quality assessment showed that the withering the tea leaves in 16 hours gave best sensory quality attributes in final product.**

**Keywords:** Withering, Trough, Tea Processing, Duration, Green leaf, Sensory quality.

## INTRODUCTION

Withering is the first step in black tea manufacturing and is known as a pre-requisite for tea processing (Borah, *et. al.*, 2012). The uniformity of oxidation during fermentationis ensured by this stage (Omiadz, *et. al.,* 2014). During this stage, the moisture content of plucked tea leaves decrease. In addition to physical changes during withering, tea leaves undergo biochemical interactions that play an important role in black tea quality; its aroma in particular (Tomlins and Mashingaidze, 1997, Singh et. al., 2012). Withering tea leaves mostly is done in open type troughs in Iran. Freshly plucked leaves spread out on fine meshed screen and air flow is blown to the leaves. With considering the determinant role of withering on the black tea quality, some researchers investigated this stage in order to improve the quality of black tea. In a research that was organized by Muthumani and Kumar in 2007, withering time duration is shortened by using freeze-withering technique. The quality of withered leaves was higher than those withered with conventional methods. In black tea manufacturing, withering is a time consuming stage (Owuor and Orchard, 1991).

Baruah *et al.* (2012) studied the effect of moisture loss and temperature during withering on formation of theaflavins (TFs), thearubigins (TRs) and volatile flavoury constituents (VFC). According to the results, with restrictive moisture loss during the initial part of withering, product quality can be improved. Also results showed that low withering temperature resulted in teas with more brightness.

With considering the withering remarkable effect on the other stages of tea processing some researchers focused on this stage from this point of view. Ullah *et. al.* (1984) investigated the effect of withering on the fermentation stage. This stage is accompanied by theaflavins (TF) and thearubigins (TR) formation. The objective of this study was developing the liquor characteristics in black tea. Results showed the polyphenol oxidase (PPO) activity affects the TF and TR formation during fermentation stage. TF and TR are associated with briskness, brightness and 'body' of tea liquors. They concluded that harder withering that is accompanied by larger reduction in moisture content result in further decreasing in PPO activity during withering. Consequently black tea loses brightness and briskness.

Omaidze *et. al.* (2014) studied biochemical processes at the stage of withering during black tea manufacturing. Results showed that during the withering stage, high-molecular forms of phenol oxidase formed which is crucial for the fermentation stage.

Tea factory capacity can be limited in peak seasons. Factories should assure the uniformity of withering in this situation (Das, 2006). So leaf handling activities before having them arrived in factory can affect the withering quality. Several researches have been conducted to investigating the designs and functional parameters of troughs. Singh, *et. al.* (2012) studied the changes in some biochemical and physical properties such as level of amino acids, polyphenol oxidase (PPO) and peroxidase (PO) activity and moisture content in customized trough during withering. During this stage, air velocity, air temperature and humidity were controlled. Results showed that withering operation could be completed with desired biochemical and physical properties in the shorter time in customized trough compared to natural withering.

This study is conducted in order to investigate withering stage and providing conditions which improve the black tea quality.

## MATERIALS AND METHODS

This study was conducted during 2014 tea plucking season in Tea Research Institute located in Lahijan County, north of Iran. Completely randomized design (CRD) and three replications were conducted, withering time duration was considered as treatment with five levels. Tea leaves comprising two leaves and a bud and three leaves and a bud were plucked by hand from Feshalam Tea Research Station, located in Fouman. Tea plucking was done in May and June 2014. The averages of air relative humidity and temperature were 72% and 23°C respectively. The average moisture content of plucked tea leaves was 73% on wet basis. Tea processing was started immediately after tea plucking. For withering operation, a laboratory 1:10 scale open type trough was designed and built. Other stages were done by miniature tea processor in Tea Research Institute. Withering time was considered as treatment with five levels (Table 1).

**Table 1 : Withering time levels.**

| Withering | Time duration |
|---|---|
| $T_1$ | 8 hours |
| $T_2$ | 10 hours |
| $T_3$ | 12 hours |
| $T_4$ | 14 hours |
| $T_5$ | 16 hours |

Withering of tea was followed by curling, oxidation and drying according to laboratory instructions as follows: Curling = one hour, Oxidation = two hours, Drying = one hour

After tea processing, colorimetry experiments, determination of tea water extract and sensory evaluation (Oragnoleptic experiments) were carried out on the samples.

*A. Colorimetry experiments*

Theaflavin content, thearubigin content, liquor tea brightness and tea liquor color were measured in these experiments. Theaflavin content was determined with the aid of spectrophotometry. TFs were extracted from 20 mL hot aqueous tea infusions with 20 mL ethyl acetate and measured the absorbance at 380 nm and 460 nm (Mahanata and Baruah, 1992).

*B. Tea water extract*

Tea water extract was obtaind from 2 grams of samples with 200 mL boiling water in a 500 mL erlenmeyer flask. After that samples were filtered and put in a crucible and dried under the temperature of 104°C in an oven for 1 hour and weighed. Tea water extract calculate with the following equation:

Tea water extract = (Crucible weight with dried tea extract-Crucible weight) / (Sample weight)

*C. Sensory evaluation (Organoleptic experiments)*

2.5 grams of tea samples were infused with 120 mL freshly boiled water for 3 minutes. The tea quality was estimated and scored by professional tea tasters. Tasters scored the appearance of dry tea, tea liquor color, taste, tea aroma and infused tea leaves as sensory indices.

Tea tasters play an important role in determining of appropriate ranges for producing tea with high quality. Liang, *et. al.* (2003), Togari, *et. al.* (1995) used this method to estimate the tea quality in their studies.

The results were analyzed with SPSS software. Duncan's Multiple Range test was used in order to comparing the means.

## RESULTS AND DISCUSSION

*A. Tea water extract*

Results showed that the effect of withering time on tea water extract was significant. Highest percent of tea water extract was related to the withered leaves in 16 hours.

**Table 2: Analysis of variance for tea water extract.**

| SOV | df | MS |
|---|---|---|
| Withering time | 4 | 5.474* |
| Error | 10 | 0.274 |
| C.V. | 1.56% | |
| **P < 0.01 | | |

Fig 1. Showed almost a rising trend of tea water extract during withering stage. Belitz *et. al.* (2009) concluded that the reduction in moisture content during withering stage can increase hydrolytic activity of some enzymes that leading to an increase in percentage of tea water extract during withering. According to the results, withering the tea leaves in 12 hours can give desired levels of tea water extract.

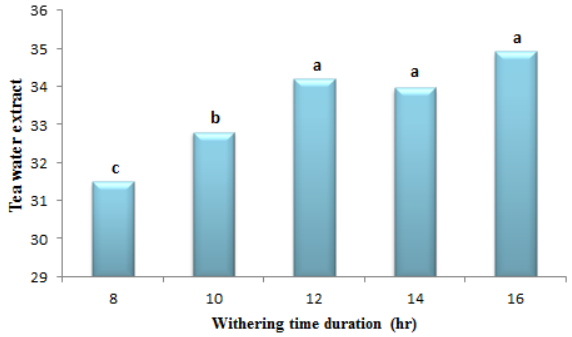


**Fig. 1.** Effect of withering time on the tea water extract.

*B. Colorimetry experiments*

**(i) Liquor color and thearubigin content.** According to Table 3, impact of withering time on liquor color of tea was significant at the 5% level. Withered leaves in 16 hours showed the highest tea liquor color. But desired infused tea color can be obtained in 12 hours, because there is no significant difference between 12, 14 and 16 hours treatments. About thearubigin, results showed that withering time affected the thearubigin content significantly.

**Table 3: Analysis of variance for liquor color.**

| SOV | df | MS |
|---|---|---|
| Withering time | 4 | 0.07* |
| Error | 10 | 0.015 |
| C.V. | 6.66% | |
| * $P < 0.05$. | | |

**Table 4: Analysis of variance for thearubigin content.**

| SOV | df | MS |
|---|---|---|
| Withering time | 4 | 1.203* |
| Error | 10 | 0.1 |
| C.V. | 4.31% | |
| * $P < 0.01$. | | |

The effect of withering time on liquor color of infused tea and thearubigin content are showed in Fig. 2. and Fig. 3., respectively. Comparison of means was carried out using Duncan's test at the 1% level. Results showed a rising trend of both liquor color and thearubigin. Ullah *et. al.* (1984) concluded that the severe withering caused an increase in thearubigin content and as a result tea liquor color and 'body' could be stronger.

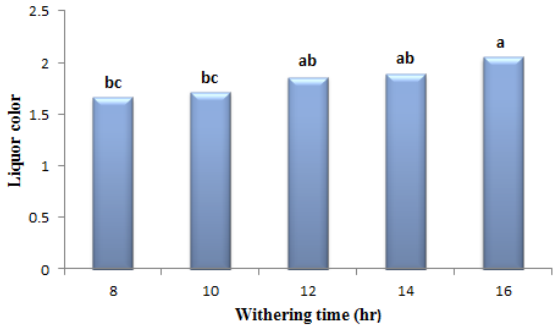


**Fig. 2.** Effect of withering time on the liquor color.

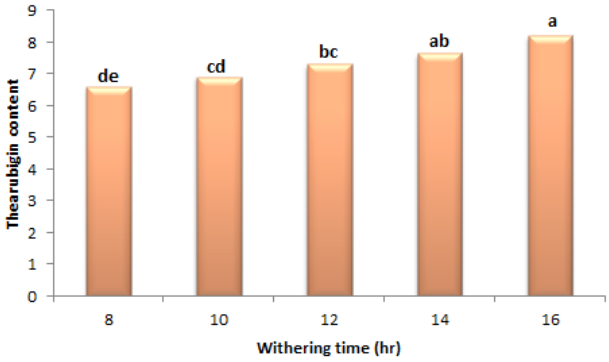


**Fig. 3.** Effect of withering time on the thearubigin content.

*(ii) Tea liquor brightness and theaflavin content*

Theaflavin is responsible for black tea brightness and briskness (Borah *et. al.*, 2012). Results showed theaflavin content wasn't affected significantly by withering time. Consequently, the effect of withering time on tea liquor brightness was none significant. Baruah *et. al*. (2012) reported that temperature play an important role in black tea brightness and lower temperature during withering can produce black tea with higher brightness.

*C. Sensory quality evaluation (Oragnoleptic experiments)*

According to the sensory quality scores, tea leaves that withered in 16 hours had the highest total quality score and leaves that withered in 8 hours had the lowest total quality score (Table 7).

**Table 5: Analysis of variance for theaflavin content.**

| SOV | df | MS |
|---|---|---|
| Withering time | 4 | 0.001$^{ns}$ |
| Error | 10 | 0.0006 |
| C.V. | 11.29% | |
| $^{ns}$ Non-significant. | | |

**Table 6: Analysis of variance for tea liquor brightness.**

| SOV | df | MS |
|---|---|---|
| Withering time | 4 | 1.265$^{ns}$ |
| Error | 10 | 0.451 |
| C.V. | 4.93% | |
| $^{ns}$ Non-significant. | | |

**Table 7: Sensory quality score of the black tea samples based on withering time treatments assessed by the tea tasters (Mean ± S.D.[a]).**

| Samples | Appearance | Liquor color | Taste | Aroma | Infused leaves | TQS[b] |
|---|---|---|---|---|---|---|
| 8 | 24.33±1.53 | 10.25±0.25 | 20.67±1.15 | 8.08±0.14 | 2.08±0.14 | 65.42±2.98 |
| 10 | 26.17±0.76 | 10.08±0.14 | 19.50±1.32 | 8.17±0.14 | 2.25±0.25 | 66.17±1.77 |
| 12 | 26.33±0.58 | 10.67±0.58 | 21.67±1.53 | 7.90±0.10 | 2.23±0.25 | 68.80±2.33 |
| 14 | 26.00±1.00 | 10.07±0.12 | 21.00±1.73 | 7.93±0.12 | 2.15±0.13 | 67.15± 2.10 |
| 16 | 28.33±0.58 | 10.93±0.12 | 24.67±1.16 | 8.83±0.76 | 3.13±0.12 | 75.90±2.33 |

[a] S.D. standard deviation, b TQS, total quality score

**Table 8: Linear correlation coefficient between qualities attributes of black tea.**

| | Appearance | Liquor color | Taste | Aroma | Infused |
|---|---|---|---|---|---|
| Liquor color | 0.483$^{ns}$ | | | | |
| Taste | 0.668$^{**}$ | 0.670$^{**}$ | | | |
| Aroma | 0.558$^{*}$ | 0.337$^{ns}$ | 0.575$^{*}$ | | |
| Infused | 0.672$^{**}$ | 0.486$^{ns}$ | 0.590$^{*}$ | 0.656$^{**}$ | |
| TQS[a] | 0.829$^{**}$ | 0.675$^{**}$ | 0.878$^{**}$ | 0.675$^{**}$ | 0.735$^{**}$ |

[a] TQS, total quality score. * $P < 0.05$, ** $P < 0.01$, $^{ns}$ non significant

Linear correlation coefficient between the total quality score and the individual tea quality attributes was significant. Liquor color has none significant linear relationship with appearance, aroma and infused tea leaves (Table 8). This suggests that a tea with high quality should have good individual tea quality attributes. Based on the results, the tea leaves that withered in 16 hours had the higher score in individual tea quality attributes.

A spider plot created to provide a graphic representation of sensory tea quality attributes for each sample. Ravichandran and Parthiban (1997) reported that the tea aroma is improved during the withering. Baruah, *et. al.* (2012) reported that longer chemical withering improved the quality of black tea taste. Owour and Orchard (1992) reported that the optimum chemical withering can be obtained in 14 hours.

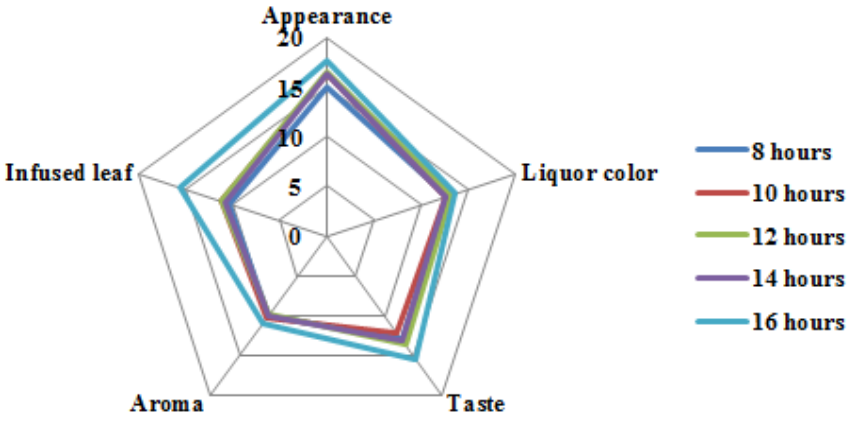


**Fig. 4.** Spider plot for sensory quality of black tea samples.

## CONCLUSION

According to the results withered leaves in 16 hours had good biochemical properties and high sensory quality score and withering in 8 hours resulted in black tea with poor biochemical and sensory quality. Also impact of withering time on liquor tea brightness when air flow rate was adjusted in 0.63 m^3/min per 1 kg green tea leaves, was none significant. All of the sensory quality attributes play an important role in tea final quality, because all of these attributes had a significant linear correlation with total quality of black tea.

Withering time duration is very crucial for biochemical attributes and controlling and monitoring this stage can help to produce black tea with high quality.

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