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Impact of withering process on sensory properties of black tea

Farshad Soheili-Fard[1*], Hamid Reza Ghassemzadeh[1], Seyed Babak Salvatian[2]

[1]*Department of Biosystem Engineering, Faculty of Agriculture, University of Tabriz, Tabriz, Iran*

[2]*Tea Research Institute, Lahijan, Guilan Province, Iran*

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Key words: Duration, Green leaf, Trough, Tea processing, Withering.

Abstract

Withering is the first step in tea processing and has a significant impact on final product quality. During the tea green leaf withering and its preparation for the next stage of processing (curling), reduction in moisture content of the leaf is accompanied by occurrence of biochemical interactions that play an important role in product quality; its aroma in particular. Air flow rate and withering time are two important parameters that affect withered tea leaves. In the present study, impact of withering on the quality of black tea product was examined based on environmental conditions and green tea quality through sensory evaluation method. A laboratory scale trough was used for withering operation. Two factors of air flow rate and withering time duration were considered with three and five levels respectively. Results showed that the impact of the air flow rate on dry tea appearance, liquor color, taste, aroma, infused leaves and final product quality (black tea) is significant at the 1% level. The interaction between air flow rate and withering time was also significant on dry tea appearance, liquor color, infused leaves and final product quality at 1%, and aroma at 5% probability levels respectively.

***Corresponding Author:** Farshad Soheili-Fard ✉ farshad.soheilifard@gmail.com

Introduction

Tea is one of the most popular none-alcoholic beverages in the world after water. Consumer acceptability of this beverage mainly depends on the taste and aroma of final product (Rawat *et al.,* 2007). Teas are usually classified into four categories as white tea, green tea, Oolong tea and black tea (Qin *et al.,* 2013). Black tea is the most consumed one on across the world (Liang *et al.,* 2003).

Several factors are involved in the quality of made black tea. These factors can be classified into several categories such as, operations related to the planting, weeding, harvesting and post-harvest operations. Post-harvest operations include handling and transportation of tea green leaf from field to the factory, processing, black tea grading and packaging. Each of these stages is effective on the quality of made tea (Liang *et al*., 2003). Among these stages, withering that is the first step in tea processing, has a significant impact on the made tea quality. This stage is known as a pre-requisite for tea processing (Borah *et al.,* 2012) and ensures the uniformity of oxidation during fermentation (Omiadz *et al.,* 2013). During the tea green leaf withering and its preparation for the next stage of processing (curling), reduction in moisture content of the leaf is accompanied by occurrence of biochemical interactions that play an important role in product quality; its aroma in particular (Tomlins and Mashingaidze 1997). Air flow rate and withering time are two important parameters that affect withered tea leaves. Open type troughs are used for withering the tea green leaf in Iran. Some researchers investigated the stage of withering in order to improve the quality of made black tea. Muthumani and Kumar (2007) organized a research on freeze-withering in black tea manufacturing. The objective of this study was reducing the withering time. Withering is a time consuming stage and tea leaves are left in the withering trough for 12-18 hours (Owuor and Orchard 1991). This action shortened the withering time of the leaves. Withered tea leaves by this method showed the higher quality in comparison to unwithered leaves and leaves with having normal withering.

Tomlins and Mashingaidze (1997) discussed the effect of using plucking standards on withering. They concluded that for having a high quality made tea, controlling the withering time, air flow rate and temperature during the withering can be crucial issues.

Leaf handling activities before having them arrived in factory has a significant effect on the withering quality. Factory capacity my not allow to handle all the materials arrived in peak seasons and the uniformity of withering should be assured by factories in this situation (Das 2006). Some researchers investigated the designs and functional parameters of troughs to improve the final product quality. Singh *et al*., (2012) studied the changes in some biochemical and physical properties such as a level of amino acids, Polyphenol oxidase (PPO) and peroxidase (PO) activity and moisture content in customized trough and natural withering. Air velocity, air temperature and humidity were controlled during the withering. They concluded that withering could be completed with desired biochemical and physical properties in the shorter time in customized trough compared to natural withering.

Withering also has a remarkable effect on the other steps of tea processing. Therefore, several studies have been conducted for investigating of withering impact on other steps of tea processing. The effect of withering on the fermentation was investigated by Ullah *et al.* (1984). The objective of this study was developing the Liquor characteristics in made black tea. During oxidation step, theaflavins (TF) and thearubigins (TR) are formed. They concluded that PPO activity that is affected by withering has significant impact on the TF and TR formation during fermentation. TF and TR are associated with briskness, brightness and 'body' of tea liquors. Results of this study showed that harder withering with larger reduction in moisture content causes further decreasing in PPO activity during withering and consequently losing brightness and briskness.

This study was conducted in order to provide conditions under which withering could be done more effectively and efficiently to improve the black tea quality.

Materials and methods

Description of data collection

This study was conducted during 2014 tea plucking season in Tea Research Institute located in Lahijan country, north of Iran. Factorial experiment with completely randomized design and three replications were conducted, air flow rate and withering time duration as the main factors with three and five levels were considered respectively. 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.

Description of experiments

A laboratory 1:10 scale trough was designed and built for withering operation. Other steps were done by miniature tea processor in Tea Research Institute. Air flow rate and withering time were considered as two factors with three and five levels, respectively (Table 1).

Table 1. Air flow rate and withering time duration.

Experimental factors	
Air Flow Rate	$A_1 = 0.6$
$(m^3/min/1\ kg\ tea\ green\ leaf)$	$A_2 = 0.63$
	$A_3 = 0.66$
Withering time Duration (hr)	$B_1 = 8$
	$B_2 = 10$
	$B_3 = 12$
	$B_4 = 14$
	$B_5 = 16$

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, sensory quality assessment on tea samples was carried out. 2.5 grams of tea sample were infused with 120 ml freshly boiled water for 3 min. The tea quality was estimated and scored by professional tea tasters. A total score of 100 was considered for grading system; 32% for the appearance of dry tea, 16% for infusion color, 32% for taste, 16% for tea aroma, and 4% for the infused leaves. This system is commonly used to assess tea quality in Iran.

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

Results and discussion

Appearance of dry tea

The average of appearance scores was calculated as 19.91, in which $A_2 \times B_5$ sample (air flow rate=0.63 m^3 min^{-1} per 1 kg tea green leaf, withering time=16 hr) had the highest appearance score and samples including $A_2 \times B_3$, $A_2 \times B_4$, $A_3 \times B_5$, $A_2 \times B_1$ and $A_2 \times B_3$ had lowest appearance score. According to the Table 2 the effect of interaction between air flow rate and withering time on the appearance of dry tea was significant.

Table 2. Analysis of variance for appearance of dry tea.

SOV	df	MS
Treatment	14	66.46**
Air flow rate	2	449.87**
Withering time	4	2.76**
Interaction	8	2.46**
Error	30	0.66
CV.	4.07%	
Average	19.91	

** P<0.01.

The effect of air flow rate and withering time on the appearance of dry tea is shown in Fig. 1. Highest appearance score belonged to $A_2 \times B_5$ (with 44% wither hardness) that was significantly higher than other samples. overally, using air flow rate up to 0.63 m^3 min^{-1} per 1 kg green leaf gave the best results for appearance.

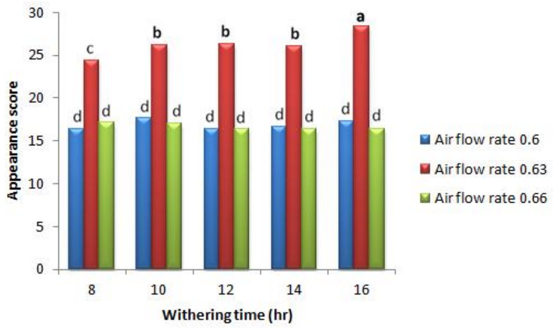

Fig. 1. Effect of air flow rate and withering time on the dry tea appearance.

In a study conducted by Tea Research Institute in Sri Lanka, hardness of wither between 40 to 43% resulted in best appearance of tea (Botheju 2011).

Liquor color of infused tea

Liquor color score had an average of 9.8. The highest score belonged to $A_2 \times B_5$ and the lowest one belonged to $A_3 \times B_3$ (air flow rate=0.66 m^3 min^{-1} per 1 kg tea green leaf, withering time=12 hr). According to Table 3, results showed that the effect of interaction between air flow rate and withering time on liquor color of infused tea was significant.

Table 3. Analysis of variance for liquor color.

SOV	df	MS
Treatment:	14	1.63 **
Air flow rate	2	7.8 **
Withering time	4	1.26 ns
Interaction effect	8	0.78 **
Error	30	0.19
CV.	4.49%	
Average	9.8	

** $P<0.01$, ns Non-significant.

Fig. 2. shows the effect of air flow rate and withering time on liquor color of infused tea. Comparison of means was carried out using Duncan's test at $P<0.01$. According to the results, withered leaves with 0.66 m^3 min^{-1} per 1 kg green leaf air flow rate had the lowest level of liquor color compared to those of other samples.

Ullah *et al.* (1984) reported the severe wither caused an increase in thearubigin content and as a result tea liquor color and 'body' could be stronger.

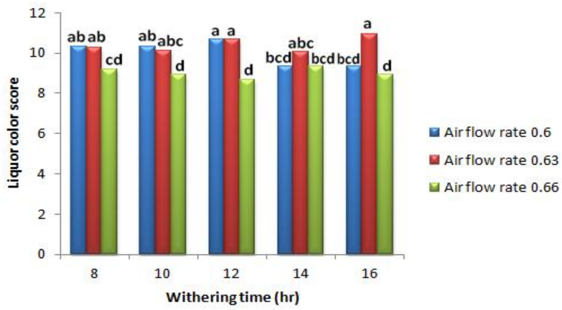

Fig. 2. Effect of air flow rate and withering time on the Liquor color of infused tea.

Taste

The highest score for taste belonged to the $A_1 \times B_5$ (air flow rate=0.6 m^3 min^{-1} per 1 kg tea green leaf, withering time=16 hr) and lowest one was related to the $A_3 \times B_5$ (air flow rate=0.66 m^3 min^{-1} per 1 kg tea green leaf, withering time=16 hr). Effect of withering time on tea liquor taste was non-significant but interaction between air flow rate and withering showed a significant effect on the tea liquor taste.

Table 4. Analysis of variance for taste.

SOV	df	MS
Treatment:	14	35.64 **
Air flow rate	2	209.54 **
Withering time	4	2.71 ns
Interaction effect	8	8.62 **
Error	30	1.7
CV.	6.2%	
Average	21.04	

** $P<0.01$, ns Non-significant.

Fig. 3. Shows that the taste score of $A_1 \times B_5$ is significantly higher than other samples and $A_3 \times B_5$ has lowest taste score. Overally, using lower air flow rate resulted in higher taste quality and the impact of

withering time had a close relationship with applied air flow. Baruah *et al.* (2012) reported that the quality of black tea taste will be improved with longer chemical withering.

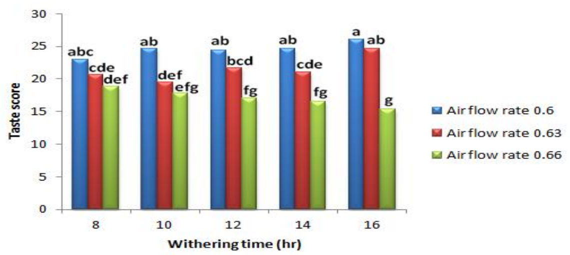

Fig. 3. Effect of air flow rate and withering time on the tea liquor taste.

Tea aroma

The average of tea aroma was calculated as 8.72 and $A_1 \times B_5$ had highest score and $A_2 \times B_3$ (air flow rate=0.63 m^3 min^{-1} per 1 kg tea green leaf, withering time=12 hr) had lowest score among all samples. According to the Fig. 4, withered leaves with air flow rate up to 0.6 m^3 min^{-1} per 1 kg tea green leaf had higher aroma score in comparison to other samples.

Ravichandran and Parthiban (1997) reported that the tea aroma is improved during the withering.

Table 5. Analysis of variance for tea aroma.

SOV	df	MS
Treatment:	14	1.41 **
Air flow rate	2	5.80 **
Withering time	4	0.72 *
Interaction effect	8	0.66 *
Error	30	0.25
CV.		5.70%
Average		8.72

** P<0.01, ^{ns} Non-significant.

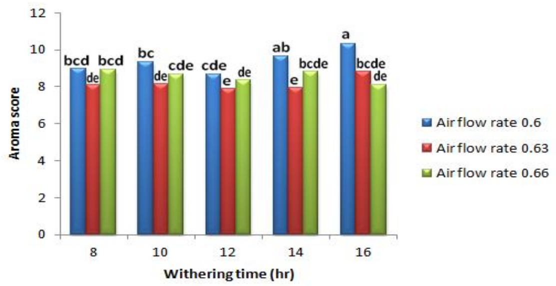

Fig. 4. Effect of air flow rate and withering time on the tea aroma.

Infused leaves

Results showed that the air flow rate with 0.6 m^3 min^{-1} per 1 kg tea green leaf resulted in higher infused leaf quality and this characteristic tended to be a function of higher orders of withering time as time passed. The effect of mentioned factors on the infused leaves is shown in Fig. 5. Duncan's test was used for comparing means. $A_1 \times B_5$ had highest score and $A_3 \times B_5$ had lowest score.

Table 6. Analysis of variance for infused leaf.

SOV	df	MS
Treatment:	14	0.96 **
Air flow rate	2	4.23 **
Withering time	4	0.47 **
Interaction effect	8	0.39 **
Error	30	0.1
CV.		12.55%
Average		2.51

** P<0.01.

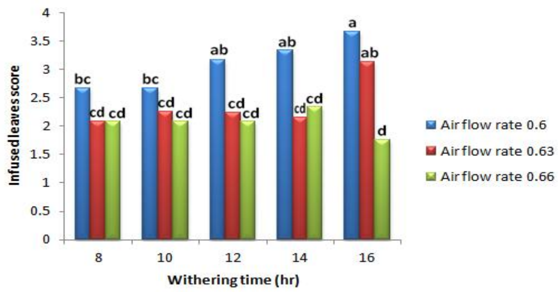

Fig. 5. Effect of air flow rate and withering time on the infused tea leaves.

Overall quality

The effect of Interaction between air flow rate and withering time on tea quality was significant at 1% level. $A_2 \times B_5$ had highest quality with the score of 75.9 and the lowest score belonged to the $A_3 \times B_4$ with the score of 50.4. According to the Fig. 6, withering with the air flow rate up to 0.66 m^3 min^{-1} per 1 kg tea green leaf degraded tea quality with passing the withering time. Higher quality of tea was obtained with 0.63 m^3 min^{-1} air flow rate per 1 kg tea green leaf as time passed the withering time improved the tea quality at this air flow rate.

Table 7. Analysis of variance for total quality score.

SOV	df	MS
Treatment:	14	154.26 **
Air flow rate	2	210.85 **
Withering time	4	3.7 *
Interaction effect	8	7.21 **
Error	30	4.37
CV.	3.37%	
Average	61.98	

* P<0.05, ** P<0.01.

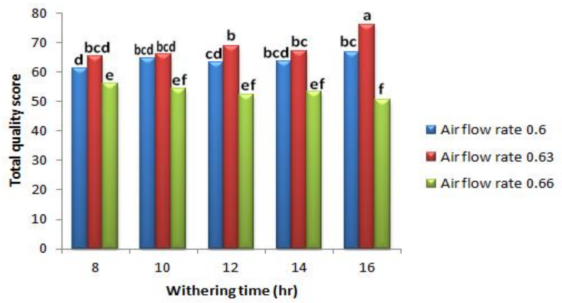

Fig. 6. Effect of air flow rate and withering time on the overall tea quality.

Owuor and Orchard (1992) reported that the desired level of biochemical interactions can be obtained during the withering. Also they mentioned that the optimum chemical withering requires 14 hours. Takeo (1984) reported withering process play an important role in the formation of volatile compounds in tea leaves during fermentation.

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.

Conclusion

According to the results, air flow rate up to 0.63 m^3 min^{-1} per 1 kg green leaf gave best results, but its interaction with withering time should be considered in black tea quality assessment. Withering with air flow rate up to 0.63 m^3 min^{-1} per 1 kg green leaf and withering time up to 16 hr resulted in highest quality and can be prescribed for withering operation in tea processing.

Monitoring the air flow rate and moisture loss of tea leaves during the withering operation assures an even withering.

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