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EFFECT OF ROLLING METHOD ON PHYSICAL CHARACTERISTICS OF ROLLED TEA LEAVES

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There are usually three periods of flush growth during a year in Turkey. In this study, harvested green tea leaves were rolled by the orthodox, Cay-kur, orthodox + rotorvane, rotorvane + 3 CTC and 3 rotorvane methods. The orthodox method curled the tea leaves better than the other methods while the rotorvane + 3 CTC method crushed and pressed the tea leaves to a greater degree. As the proportion of substandard tea leaves increased due to ageing at the end of the periods of flush growth the leaves were not sufficiently rolled by the orthodox method unlike the uniform rolling obtained by the rotorvane + 3 CTC and 3 rotorvane methods at each period of flush growth. Colour transformation increased more effectively during the oxidation period in tea leaves rolled by the rotorvane + 3 CTC method than in the leaves rolled by the other methods.

INTRODUCTION

The recommended plucking standard for tea leaves is two or three leaves and a bud (Harler, 1963; Ullah, Gogsi and Baruah, 1984; Mahanta *et al.*, 1988). Under commercial tea production it is difficult to obtain tea shoots which meet this standard, particularly if the tea is harvested with shears (Nas, 1990).

The distribution of tea crops is atypical in Turkey. After a severe winter, the temperature suddenly rises in the spring and the tea season starts in late May and the tea crop becomes ready for harvesting at nearly the same time. Tea is plucked three times (or rarely, four times) until October, depending on weather conditions. In general, in Turkey there are three periods of flush growth. The interval in days between the beginning and end of each flush period is about 32 to 33 days. Each period of flush growth is followed by a dormant phase that lasts for about 20 to 25 days. The crop yield decreases successively from the first generation of flush growth to the third. About 45% of the annual yield is harvested during the first generation of flush growth. As a result it is not possible to harvest all of the tea at its optimal harvesting time. The final harvest occurs about 32-33 days after the first harvesting day. This results in the tea leaf becoming aged with a corresponding decrease in quality because the proportion of substandard leaves increases under these harvesting conditions. The difficulty in harvesting the green tea at optimal times is a very big handicap in the black tea manufacturing process.

[1] The Institute does not necessarily endorse the views expressed in papers contributed by persons other than members of its staff.

The rolling and oxidation phases are the most important processing steps in black tea production for the development of desired quality characteristics. In tea producing countries black tea processing systems are named according to the rolling methods applied. The four main processes generally used are the orthodox, rotorvane, CTC (crushing, tearing, curling) and LTP (Lawrie Tea Processor). These processes can also be used in different combinations (Harler, 1963; Werkhoven, 1974; Cloughley, Ellis and Harris, 1981; Van Lelyveld and De Rooster, 1986). The orthodox method is very commonly employed in Turkey and around 90% of black tea is processed by this method or by the Cay-kur method which is the combination of this method and the rotorvane (Orthodox + rotorvane + pressed orthodox). In Turkey, the rotorvane method and more importantly the CTC method have come into use during the last ten years.

During tea processing, the degree of curling, crushing and pressing of the tea leaves vary according to the rolling method used and the characters of the green tea leaves. Hence, much of the developed characteristics of black tea strictly depend on the processing system (Cloughley *et al.*, 1981; Harris and Ellis, 1981; Takeo and Mahanta, 1983; Hazarika, Mahanta and Takeo, 1984; Van Lelyveld and De Rooster, 1986). This paper reports a study of the effect of the orthodox, Cay-kur, orthodox + rotorvane, rotorvane+ 3 CTC and 3 rotorvane rolling methods on tea manufacture. The degree of colour transformation which occurs in the rolled tea leaves during the oxidation period has also been compared among the different methods of rolling. It is hoped to publish the results of a study of the value of some quality parameters such as theaflavin, thearubigin, total colour and brightness of black tea processed by these methods in a later article. The objective of these series of studies is to identify and adopt a suitable method of tea rolling for the conditions obtaining in Turkey.

MATERIALS AND METHODS

Harvested green tea leaves from the fields of 45 smallholders were used as the raw material in this experiment. These tea fields are located in the village of Kalkandere, near Rize. Kalkandere is one of the areas in Turkey which has many tea plantations and is around 200 m amsl experiencing about 2300 mm annual rainfall. All the tea fields of the smallholders are sited in the same locality and are contiguous; they belong to the same tea purchasing area. Green tea material harvested by shears from each of three generations of flush growth as well as from the beginning, middle and the end of each flush growth period, was used in this study. On each occasion a representative homogenous sample of 1000 ± 100 kg of green tea leaves were used.

The tea leaves were withered for five hours and a stream of air at a temperature of 32 ± 2°C, was blown through them. The leaves were mixed by hand at the middle of the withering time. In all instances the leaves were subjected to the same degree of wither (i.e. 66% moisture). This was done to eliminate any effects due to varying withering levels.

The withered leaves were processed by 5 different methods under commercial factory conditions:

1. Orthodox method: unpressed rolling (40 min) + sifting + rolling with press (applied as intervals of 5 min unpressed, 5 min pressed, total of 35 min) + sifting.

2. Cay-kur method: unpressed rolling (40 min) + rotorvane + sifting + rolling with press (20 min) + sifting.

3. Orthodox + rotorvane method: unpressed rolling (40 min) + rotorvane + sifting.

4. Rotorvane + CTC method: rotorvane + 3 x CTC

5. Rotorvane method: 3 x rotorvane + sifting

The rolled leaves were oxidised by a stream of air, at a temperature of 25 ± 2°C for 90 min.

Determining the efficiency of the rolling methods

A sample of 100 g of rolled tea leaves was taken and spread on a white laboratory table. The effects of the different rolling methods on the rolled tea were determined by considering the following parameters: The degree of (a) curling, (b) crushing, (c) pressing, (d) juiciness and (e) overall appearance. The characters of (a), (b), (c) and (e) were appraised as very good, good, fair or insufficient. Juiciness was determined as being too much, a lot, normal or dry. The juiciness of the rolled leaf was evaluated by placing a handful of the tea sample in the palm and squeezing it. All these organoleptic evaluations were carried out by a panel of three people rigorously trained in this procedure.

Determining colour transformation during oxidation

At the end of the oxidation period, 100 g of the tea sample was spread on a white laboratory table and the degree of colour transformation in the oxidised tea was determined by the same panel according to the tone of the colour. These colour values were graded as copper red 10, 9; reddish 8,7,6; greenish 5,4,3; blackish 2, 1. The tone and appearance of colour varied depending on the distance from which the leaves were observed. Hence, the leaf particles were always observed from a distance of 25-40 cm.

RESULTS AND DISCUSSION

It was found that the period of flush growth, the different times within each such period as well as the different processing methods had a significant effect on some of the physical characteristics of rolled tea, such as degree of curling, crushing, pressing and overall appearance (Tables 1-3). The orthodox rolling method resulted in better curling than the other methods; however, the degree of curling varied for each period of flush growth and also at the different times within each such period. The effectiveness of curling was better with the orthodox method followed by the Cay-kur, orthodox + rotorvane, 3 rotorvane and rotorvane + 3 CTC methods. But it was not possible to obtain sufficient rolling by the orthodox method when tea leaves were harvested at the end of the period of flush growth. This was attributed to the duration of the rolling time, the severity of pressing, some features of the orthodox machines and the toughness of the green tea leaves obtained during this period.

The orthodox, Cay-kur and orthodox + rotorvane methods were not able to achieve uniform crushing and pressing of the tea leaves harvested from the different periods of flush growth nor at different times within each such period. The orthodox method, in particular, could not crush and press tea leaves sufficiently. The rotorvane + 3 CTC was the best method for crushing and pressing tea leaves in each period of

TABLE 1 – *Determining the efficiency of rolling methods (1st period of flush growth)*

Methods	Period of flush growth	Efficiency of rolling																			
		Curling				Crushing				Pressing				Juiciness				Overall appearance			
		VG	G	F	I	VG	G	F	I	VG	G	F	I	TM	L	N	D	VG	G	F	I
Orthodox	Beginning		+					+				+				+			+		
	Middle		+				+				+					+			+		
	End				+				+				+			+					+
Cay-kur	Beginning		+			+					+						+		+		
	Middle			+				+			+						+			+	
	End			+			+					+				+				+	
Orthodox + rotorvane	Beginning			+		+				+						+			+		
	Middle			+			+				+					+			+		
	End				+			+			+					+				+	
Rotorvane + 3 CTC	Beginning				+	+				+						+			+		
	Middle				+	+				+						+		+			
	End				+	+				+						+			+		
3 rotorvane	Beginning				+	+				+							+		+		
	Middle				+	+					+				+				+		
	End				+	+				+						+			+		

1) VG – Very Good, G – Good, F – Fair, I – Insufficient, TM – Too much, L – A lot, N – Normal, D – Dry.
2) When the assigned points deviate from the standard lines, it means the panel was unable to decide which category best described the results.

TABLE 2 – *Determining the efficiency of rolling methods (2nd period of flush growth)**

Methods	Period of flush growth	Efficiency of rolling																			
		Curling				Crushing				Pressing				Juiciness				Overall appearance			
		VG	G	F	I	VG	G	F	I	VG	G	F	I	TM	L	N	D	VG	G	F	I
Orthodox	Beginning			+					+				+			+					+
	Middle		+					+				+			+					+	
	End				+				+				+			+					+
Cay-kur	Beginning			+			+			+					+				+		
	Middle		+					+				+			+					+	
	End			+			+					+					+			+	
Orthodox + rotorvane	Beginning		+					+			+				+				+		
	Middle			+				+				+			+					+	
	End				+			+			+				+					+	
Rotorvane + 3 CTC	Beginning				+	+				+						+			+		
	Middle				+	+				+						+			+		
	End				+	+				+						+			+		
3 rotorvane	Beginning			+			+				+					+			+		
	Middle				+		+				+				+				+		
	End				+		+			+					+				+		

* Abbreviations and other explanations are same as in Table 1.

TABLE 3 – *Determining the efficiency of rolling methods (3rd period of flush growth)**

Methods	Period of flush growth	Efficiency of rolling																			
		Curling				Crushing				Pressing				Juiciness				Overall appearance			
		VG	G	F	I	VG	G	F	I	VG	G	F	I	TM	L	N	D	VG	G	F	I
Orthodox	Beginning			+				+				+			+					+	
	Middle				+			+					+			+				+	
	End			+				+			+					+				+	
Cay-kur	Beginning			+				+			+					+			+		
	Middle			+				+		+					+				+		
	End			+				+			+					+				+	
Orthodox + rotorvane	Beginning			+				+			+					+				+	
	Middle			+			+				+				+				+		
	End			+			+				+					+			+		
Rotorvane + 3 CTC	Beginning																				
	Middle	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	End																				
3 rotorvane	Beginning				+	+				+						+			+		
	Middle				+	+				+						+			+		
	End				+	+				+						+			+		

* Abbreviations and other explanations are same as in Table 1.

(–) Black tea could not be produced with the rotorvane + 3 CTC method during the 3rd period of flush growth.

flush growth although adequate curling of the leaves were not obtained. The 3 rotorvane method was the second best method for pressing and crushing. All the stems were also crushed and pressed in the tea shoots rolled by the rotorvane + 3 CTC and the 3 rotorvane methods. The degree of crushing of the stems was less in the tea leaves rolled by the orthodox method than in the leaves rolled by the other methods. The stems were generally crushed into pieces of 1-4 cm in length by the orthodox method and they did not lose all their characters because they were not pressed hard enough. Both the Cay-kur and the orthodox + rotorvane methods crushed the stems into 0.5-3 cm length pieces and it was seen that these methods also pressed the stems to some extent.

Although, the juiciness of the rolled tea samples was not significantly affected by the different rolling methods, it could be seen that the different methods as well as the degree of rolling had an effect on the juiciness of the tea samples which had been withered to almost the same level. Juiciness, in particular depended on the withering process and the water content of the withered tea. When the overall effects of rolling, curling, crushing, pressing, juiciness and appearance are considered the best rolling was obtained by the rotorvane+3 CTC rolling method followed respectively by 3 rotorvane, orthodox + rotorvane, Cay-kur and orthodox methods.

At the end of the oxidation period, a significant degree of colour transformation was seen in the tea leaves rolled by the rotorvane + 3 CTC method than in the leaves rolled by the other methods (Table 4). The rotorvane + 3 CTC method ranked next as far as the degree of colour transformation was concerned.

TABLE 4 – *Colour transformation values at the end of the oxidation period (10,9 - copper red; 8,7,6 - reddish; 5,4,3 - greenish; 2,1 - blackish)*

Methods	*Period of flush growth*	*First flushing*	*Second flushing*	*Third flushing*
Orthodox	Beginning	6	5-6	6
	Middle	7	5-6	6
	End	6	5-6	6
Cay-kur	Beginning	6	6-7	6
	Middle	5	7	6-7
	End	6	5	6
Orthodox + rotorvane	Beginning	5	5	6
	Middle	6	7	6
	End	6-7	6	6
Rotorvane + 3 CTC	Beginning	5-6	7	-
	Middle	7-8	8	-
	End	7-8	8	-
3 rotorvane	Beginning	5	6	6
	Middle	6	6	7
	End	7-8	6	7-8

(-) Black tea could not be produced with the rotorvane + 3 CTC method in the third period of flush growth.

There were no noticeable colour differences among tea leaves rolled by the orthodox, Cay-kur and orthodox + rotorvane methods. From these results, it could be concluded that there is an important relationship between the degree of damage to the cellular integrity of tea leaf tissues and the development of colour during the oxidation period.

As the results of this study indicate the significance of the rolling methods in black tea manufacture it is of paramount importance to choose the appropriate method of rolling in Turkey as well as in all other tea producing countries.

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