

## Comparison with Threshold Limit Value (TLV) of Menthol Cigarettes between Expert and Consumer Panel

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**ABSTRACT** : Threshold limit value (TLV) test between expert and consumer panel was conducted about absolute, recognition and difference threshold respectively. And we tried to suggest appropriate and minimum acceptable menthol concentration level by consumer panel. Determination of threshold value was based on ASTM E 679-79 method by forced-choice ascending concentration series. In addition, a semi-ascending paired difference method was referred to conduct test. The group threshold value was determined as the value of geometric mean individual threshold. The smokers were divided by two groups, trained and consumer panel. Trained panel was selected according to sensitivity to menthol discrimination. Consumer panel was recruited in proportion as population ratios including female smokers. They were all over twenty years old volunteers and summed up thirty four persons. In terms of sensory evaluation, overall difference test with seven-category scale by both trained and consumer panelists were done. On judging correct or incorrect answer, two by three cut-off levels applied to. Every test was conducted with two sessions, before smoking and during smoking period. And, only two samples served each panel per test with regard to sensory fatigue and reliable results. All tests were replicated, and in total 32 times per panelist. In conclusion, the recognition threshold about consumer and expert panel was 358 ppm/cig. and 276 ppm/cig. in separately. Besides, absolute and difference thresholds were obtained also. And, we conduct difference threshold test with two different ways, upward and downward. And, The results of each method were 246, 195 ppm/cig., 1414, 1336 ppm/cig. and 1047, 972 ppm/cig.

**Key words** : threshold limit value, menthol discrimination

Thresholds may also be used as a means of selecting or testing panelists, but this should not be the principal basis for selection unless the test objective requires detection of the stimulus at very low levels. The threshold of added desirable substances may be used as a research tool in the formulation of foods, beverages etc. The concepts of the Odor Unit (Guadagni et al., 1966) or Flavor Unit (Meilgaard, 1975) use the

threshold as a measure of flavor intensity. The methods by which olfactory thresholds are determined can have a profound influence on the results. Meilgaard(1999) said that subjects will pride themselves and hope to please the experimenter by finding the lowest threshold. Namely, thresholds are the limit of sensory capacities (Meilgaard et al., 1999). It is convenient to distinguish between the absolute

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threshold, the recognition threshold, the difference threshold and the terminal threshold. At first, the absolute threshold (detection threshold) is the lowest stimulus capable of producing a sensation such as, dimmest light, the softest sound, the lightest weight, the weakest taste. The recognition threshold is the level of a stimulus at which the specific stimulus can be recognized and identified. It is usually higher than the absolute threshold. The difference threshold is the extent of change in the stimulus necessary to produce a noticeable difference. It is usually determined by presenting a standard stimulus which is then compared to a variable stimulus. At last, the terminal threshold is that magnitude of a stimulus above which there is no increase in the perceived intensity of the appropriate quality for that stimulus; above this level, pain often occurs.

In this research, we focused on three thresholds with the exception of terminal. Threshold limit value (TLV) test between expert and consumer panel was conducted about absolute, recognition and difference threshold with mentholated cigarettes respectively. Menthol related studies have been conducted by many researchers (Rhee et al, 1989; Park et al, 1979; Yang et al, 1984; Kwag et al, 2003; Baek et al, 2003). But, the research involved in TLV was not found out in domestic studies. Whereas, we found that a number of menthol threshold studies were

conducted about forty years ago and still continue today by foreign tobacco companies (B&W documents, 1982; Harry T.L. et al, 1999; PM documents, 1978; RJR documents, 1968).

## Materials and methods

### Sample preparation

We used medium tar cigarette consist of flue-cured (F.C.), burley (Br.), oriental (Ori.), cut rolled stem (CRS) and reconstituted tobacco leaf (RTL) by paper making process. Flue cured consisted of AB3, B1, C1 and CD3, and burley was same grade. These five kinds of grades are known as common in Korea. We used mono acetate filter with 2.7/35,000 tow, 108 mm, 3627 Pa(370 mmH<sub>2</sub>O). And, tipping paper was 500 CU porosity with two layers laser perforation. Besides, cigarette paper was flax with 45 CU porosity. And, menthol was natural and origin of Brazil. At the preliminary test, we used the origin of China. But, we should substitute it for the origin of Brazil, because of the purity of menthol. From flue cured to RTL, all raw materials' blending ratio and constitutions were displayed as follows. In addition, burley was no casing. In case of oriental leaves, izmir, basma and krumovgrad were all the I/III grade. Mentholated sample cigarette making was designed by three categories, likewise absolute, recognition and detection threshold. For absolute

Table 1. The blending ratio of sample cigarette constituent

Blending Ratio	Constitution Ratio
Flue-cured (38 %)	AB3 20 % + B1 30 % + C1 30 % + CD3 20 %
Burley (18 %)	AB3 20 % + B1 30 % + C1 30 % + CD3 20 %
Oriental (11 %)	Izmir( I/III) 30 % + Basma( I/III) 50 % + Krumovgrad( I/III) 20 %
Cut-rolled stem (19 %)	F.C. A2 25 % + F.C. A3 25 % + F.C. B2 25 % + F.C. B3 25 %
Reconstituted tobacco leaf (14 %)	Paper making type 100 %

and recognition threshold test, menthol concentration was adjusted to the low level, 120, 240, 480 ppm/cig. in comparison with no treatment sample. Whereas for the detection threshold test it was centered at 8,000 ppm/cig. on the basis of current domestic menthol products. That is, we conducted upward and downward test. Table 1 explains the blending ratio of sample cigarette.

**Menthol applicator**

In order to conduct threshold test, we designed and made menthol applicator. We called this apparatus “Additive Loading Kit”, as shorten name is “ALK”. In explanation of operating principles, in the first step, the cigarette mounting holder approaches the syringe port. Next, the syringe plunger starts the cigarette injection as the cigarette mounting holder moves away simultaneously. So, an accurate measured volume is uniformly injected into the sample cigarettes. After the injecting solution is exhausted, the syringes are displaced manually for refilling. Fig. 1 shows the main compartment of injection ports.

**Test method**

According to threshold test method, we chose an ascending forced choice method recommended by ASTM E679-79(ASTM, 1991a) over different ways because of their suitability and reliability.

**Threshold value calculation**

On Calculation, Best-Estimate Threshold (BET) method was applied in the same way of Table 2. BET concentration for the panelist is then the geometric mean of that concentration at which the last miss answer occurred and the next higher concentration designed by a correct response. At this point, log to the base ten values was used in order to reduce deviation, and ten to the power n value was applied to restore the true value. On condition that more than a half of group perceives the difference, at that point group threshold acquired. An expert on sensory evaluation field, Morten Meilgaard(1999) says that population threshold is defined generally as a stimulus intensity that produces a response in half of the trials.

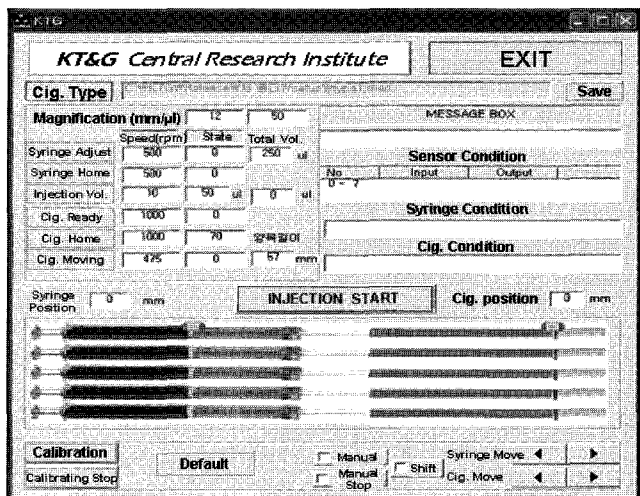
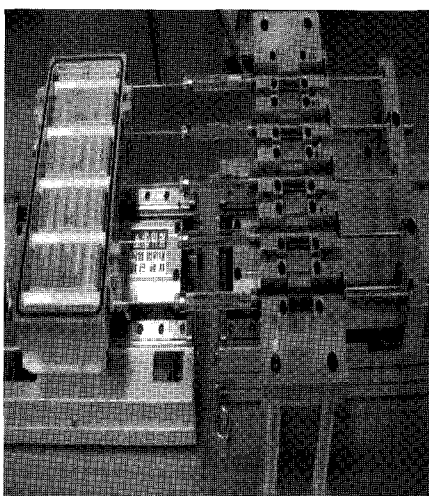


Fig. 1. Main compartment of injection ports and control program of menthol applicator.

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Table 2. Example of threshold calculation by best-estimate threshold

Panelists	Judgments						Best-Estimate Threshold (BET)	
	Dilution Factors							
	Concentration Increase →						Value	Log <sub>10</sub> of Value
	3,645	1,215	405	135	45	15		
1	0*	+	+	0	+	+	78	1.89
2	+	0	+	+	+	+	701	2.85
3	0	+	0	0	+	+	78	1.89
4	0	0	0	0	+	0	9	0.94
5	+	0	0	+	+	+	234	2.37
6	+	+	+	+	+	+	6,313	3.80
7	0	+	+	0	+	+	78	1.89
8	+	0	0	+	+	+	234	2.37
9	+	0	+	+	+	+	6,313	2.85
Group BET geometric mean							ΣLog <sub>10</sub> ▶ 20.85	
Standard Deviation 10 <sup>n</sup> (n = 2.32)							0.81 209 ◀ 2.32 (Mean)	

\* "0" : indicates that the panelist selected the wrong sample of the set of samples

"+" : indicates that the panelist selected the correct sample

**Sensory evaluation**

On sensory evaluation, overall difference test with seven-category scale by both trained and consumer panelists were done. On judging correct or incorrect answer, two by three cut-off levels

applied to this calculation method. Every test was conducted with two sessions, before smoking and during smoking period. And, only two samples served each panel per test with regard to sensory fatigue and reliable result. All tests

Table 3. Recruited consumer panel according to quota sampling

Occupation		White Collar		Blue Collar		Self-employed		Student		Subtotal	
Sex	Age	Quota	Recruiting	Quota	Recruiting	Quota	Recruiting	Quota	Recruiting	Quota	Recruiting
Male	20~24	1		1	1	—	—	3	4	5	5
	25~29	2	2	2	2	1	1	—	—	5	5
	30~34	2	2	2	2	1	1	—	—	5	5
	35~39	2	2	2	2	1	1	—	—	5	5
	40~44	2	2	2	2	1	1	—	—	5	5
	45~49	1	1	1	1	1	1	—	—	3	3
	50~54	1	1	—	—	1	1	—	—	2	2
	55~59	1	1	—	—	1	1	—	—	2	2
Female	35~39					1	1			1	1
	40~44					1	1			1	1
Total		12	11	10	10	9	9	3	4	34	34

were replicated, and in total 32 times each panelist.

**Panel selection**

Consumer panel recruitment was conducted in accordance with quota sampling. In proportion to the smoker ratio, thirty four consumer panel members were recruited by their occupations, sex and age to include female smokers as Table 3. The other information such as, year of smoking, the amount smoked per a day were also acquired from the questionnaire. They were all over twenty years old volunteers. Besides, every expert panelist in our company has been monitored and tracked regarding as sensitivity, reproducibility, agreement and cross-over. So, we selected the best 10 panelists in these four categories. They were all male panelists.

**Results and discussion**

Table 4 shows the four kinds of menthol threshold limit value before lighting session by

consumer and expert. That is, discrimination test was conducted by sniffing method. This demonstrates the before lighting session, referred to as the sniffing or olfactory test. Each TLV concentration, parts per million per cigarette value was obtained. As for the difference thresholds, upward and downward tests were conducted as a base line using a concentration of eight-thousand ppm per cigarette. That standard concentration was equivalent to the main menthol product having been sold in current market. On the whole, expert panel shows the higher discriminating ability. Strictly speaking, there were no significant differences between the two groups. Additionally, on a difference threshold, downward value came out lower than upward value. In other words, menthol reducing amount was more sensitive than the adding amount irrespective of panel groups.

The other results were given at Tble 5 contrary to the lighting session. Likewise, during smoking session, similar tendencies were obtained. And, downward value found out lower than upward

Table 4. Results of threshold limit value before lighting session by two panel groups (Unit : ppm/cig.)

	Consumer	Expert
Absolute threshold (ATLV)	297	270
Recognition threshold (RTLTV)	352	339
Difference threshold (DTLV)_ upward	1,336	1,179
Difference threshold (DTLV)_ downward	1,318	1,061

Table 5. Results of threshold limit value during smoking session by two panel groups (Unit : ppm/cig.)

	Consumer	Expert
Absolute threshold (ATLV)	246	195
Recognition threshold (RTLTV)	358	276
Difference threshold (DTLV)_ upward	1,414	1,336
Difference threshold (DTLV)_ downward	1,047	972

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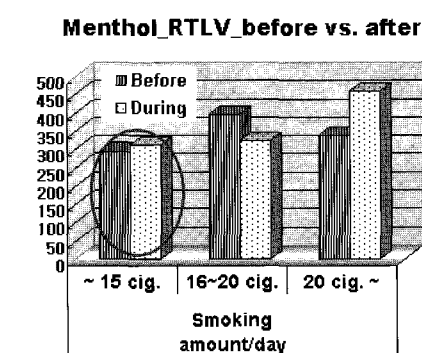
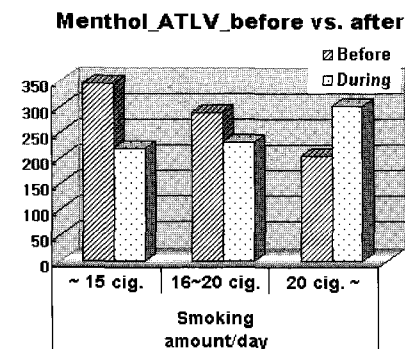
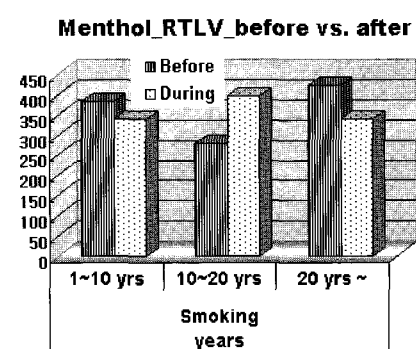
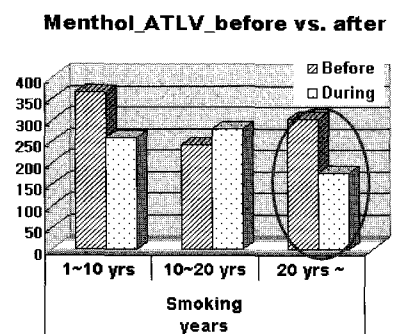
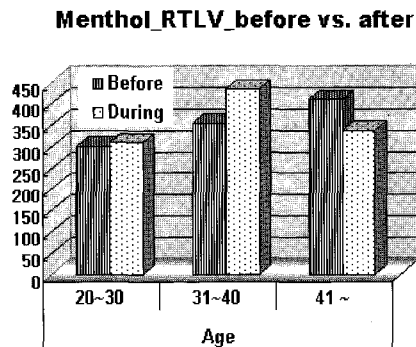
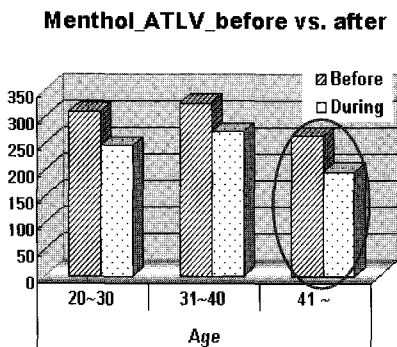


Fig. 2. The absolute threshold value of consumer panel by age, smoking years and smoking amount per a day.

Fig. 3. The recognition threshold value of consumer panel by age, smoking years and smoking amount per a day.

value at difference threshold as well.

Consumer's data was reanalyzed in order to find out properties by different characteristics for two sessions. We compared that data according to three characteristics, such as, their age, years of smoking and the amount smoked cigarette per

a day. Fig. 2 illustrates the acquired absolute threshold value about three features.

We found that the older people were and the number of years smoking resulted in a higher discriminating ability. The recognition threshold value also showed in Fig. 3. That explains the

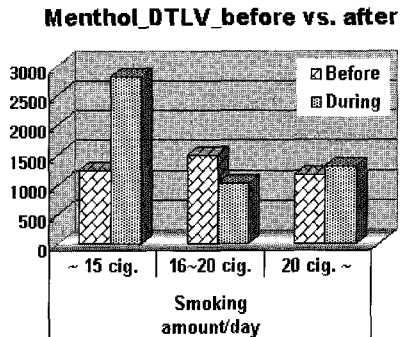
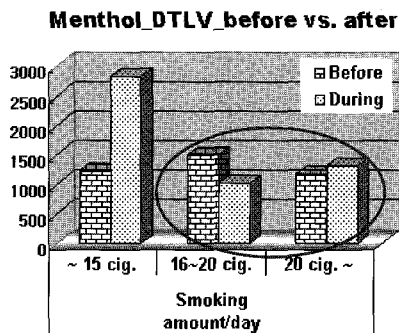
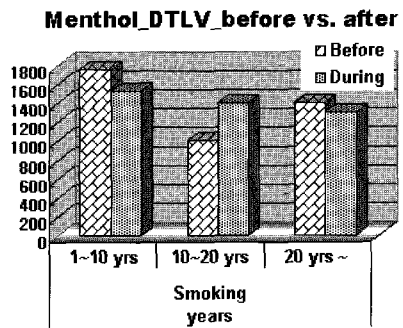
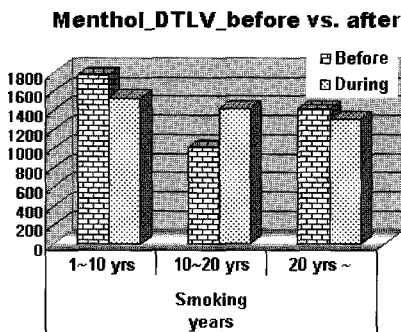
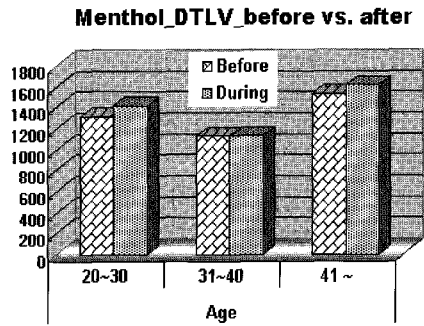
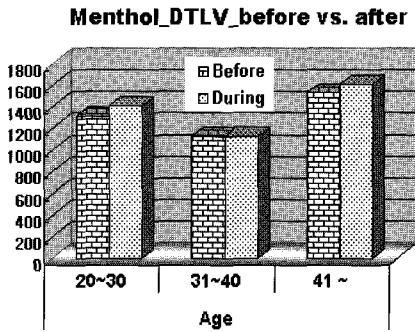


Fig. 4. The difference threshold value of consumer panel about upward by age, smoking years and smoking amount per a day.

Fig. 5. The difference threshold value of consumer panel about downward by age, smoking years and smoking amount per a day.

less smoking amount per a day's group does results in a higher discrimination rate.

But, in terms of differential threshold express different ways on the other side. The peculiar thing is that it shows the more smoking amount per a day's group shows the higher discrimination.

The similar aspects were taken both upward and downward as indicated below Fig. 4 and 5.

In conclusion, these results demonstrate that the threshold study is useful for acquisition of different consumer perception ability. As the basis of preceding studies, we found out the

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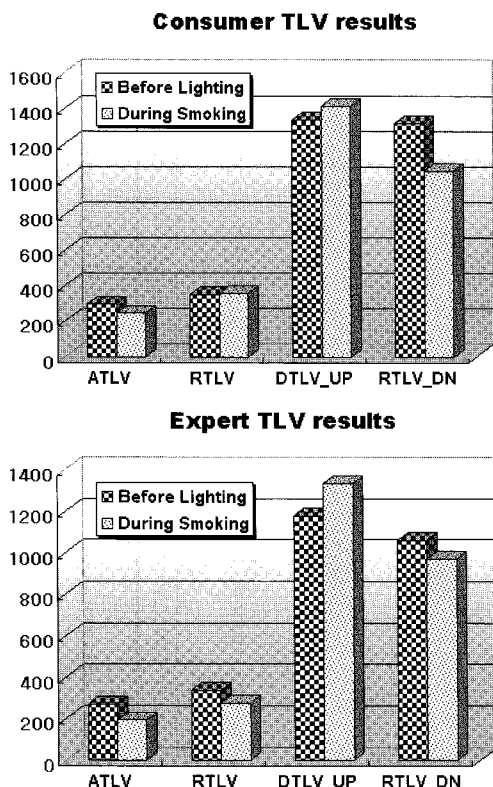


Fig. 6. Overall threshold limit value about consumer and expert panel.

consumer perception levels about absolute, recognition and difference threshold respectively. So, we finally formed the base of further study about the other additive threshold limit value. Fig. 6 shows about overall results.

### Conclusion

In this research, we focused on three thresholds with the exception of terminal. Threshold limit value (TLV) test between expert and consumer panel was conducted about absolute, recognition and difference threshold with mentholated cigarettes, respectively. In conclusion, the recognition threshold about

consumer and expert panel was 358 ppm/cig. and 276 ppm/cig. in separately. Besides, absolute and difference thresholds were obtained in the same way. And, we carried out difference threshold test with two different ways, upward and downward. And, each result was 246, 195 ppm/cig. 1414, 1336 ppm/cig. and 1047, 972 ppm/cig.

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