

Thermal Time Model in Studying Changes of Aroma Components in Cigarettes During Storage

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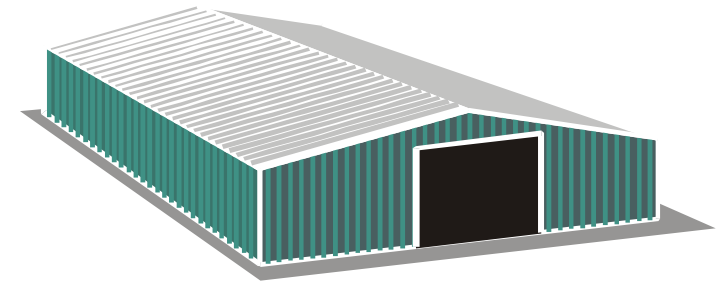
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Contents

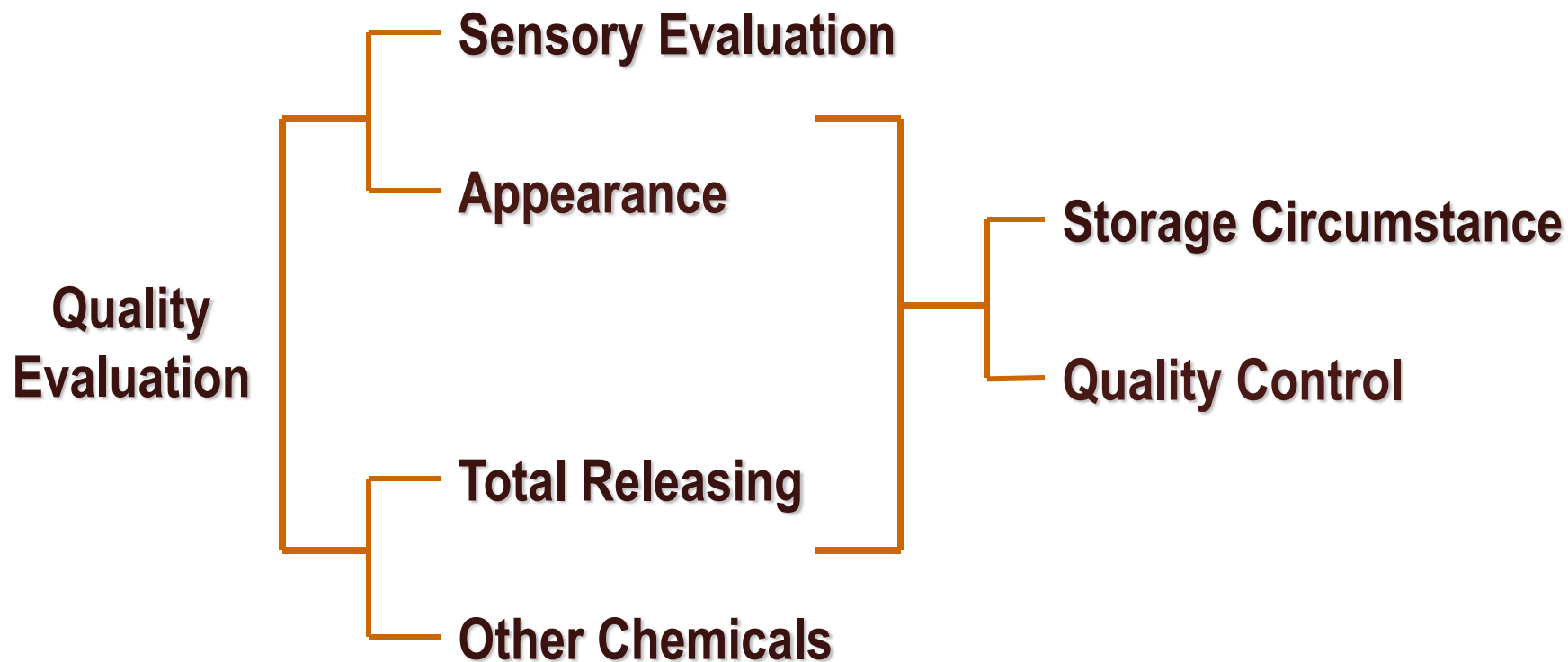
- ❖ Introduction
- ❖ methods & Principles
- ❖ Results & Discussion
- ❖ Conculsion
- ❖ Acknowledgements



Part 1

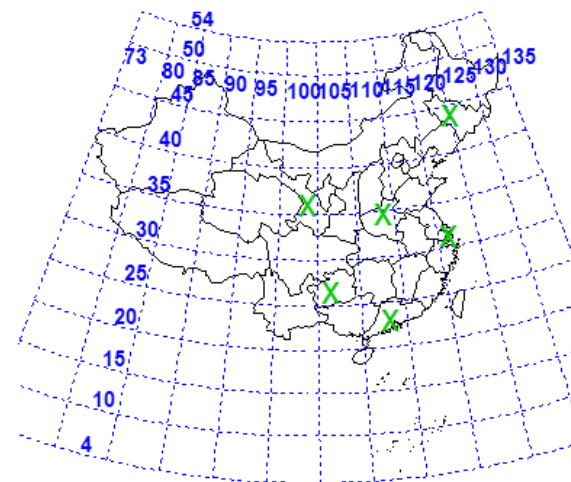
Introduction

“Storage of Cigarettes”

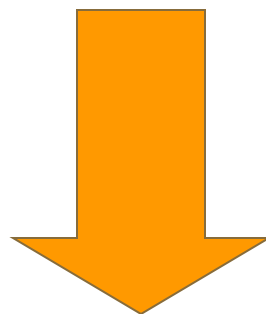


Sampling

Two years experiments



Quality monitor every three months



Sensory evaluation, physical and chemical measurements

Part 2

Methods

“Triangle ”

“Brightness”

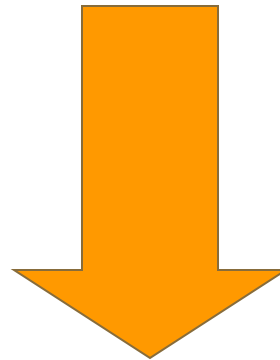
“GC/MS”

.....

Data visualization

**Temperature & Moisture
effect**

**Seasons and cities
Discriminant**



Quality Evaluation & control

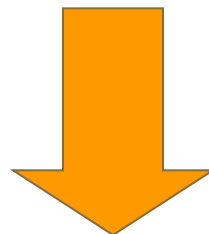
Cross validation

Thermal Time Models

(Generalized) Linear Models

Monte-Carlo Simulation

PCA



Further research

“Data visualization”

Part 3

Results & Discussion

“Quality Changes”

Thermal Time Models of chemicals

Assuming a time span: $\Delta t = 1\text{day}$

$$R = \alpha \cdot (T_d - T_t) \quad \alpha < 1$$

R (Velocity), T_d (Mean of daily temperature), T_t (Initial temperature), α (Velocity constant). While R is equivalent to the inverse of the number of days that the chemical components decreased:

$$R = \frac{1}{\sum_{d_1}^{d_2} \Delta t}$$

Velocity of 1 day that chemical components decreased:

$$R \cdot \Delta t = \left[\frac{1}{\sum_{d_1}^{d_2} \Delta t} \right] \cdot \Delta t$$

Velocity from d_1 to d_2

$$\sum_{d_1}^{d_2} (R \cdot \Delta t) = 1$$

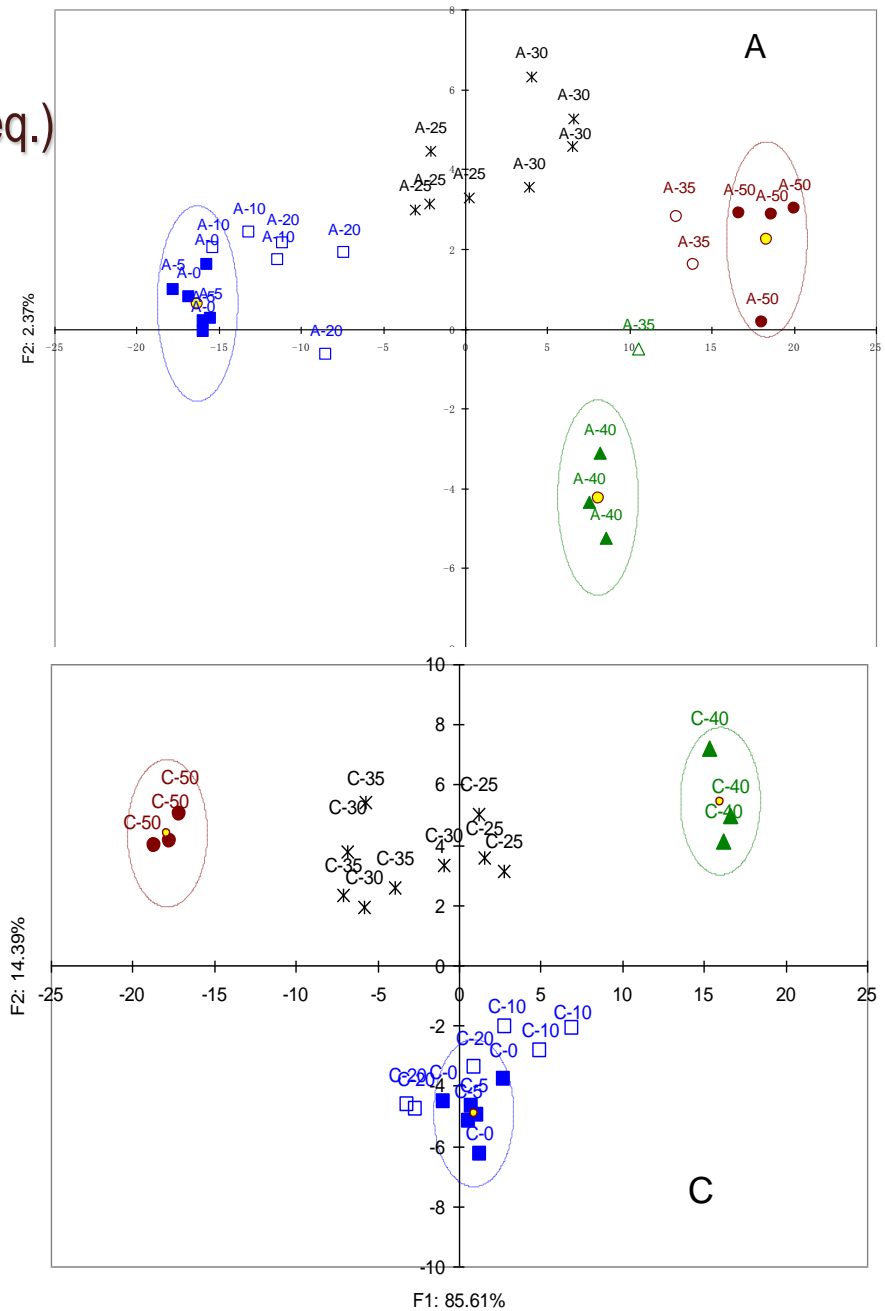
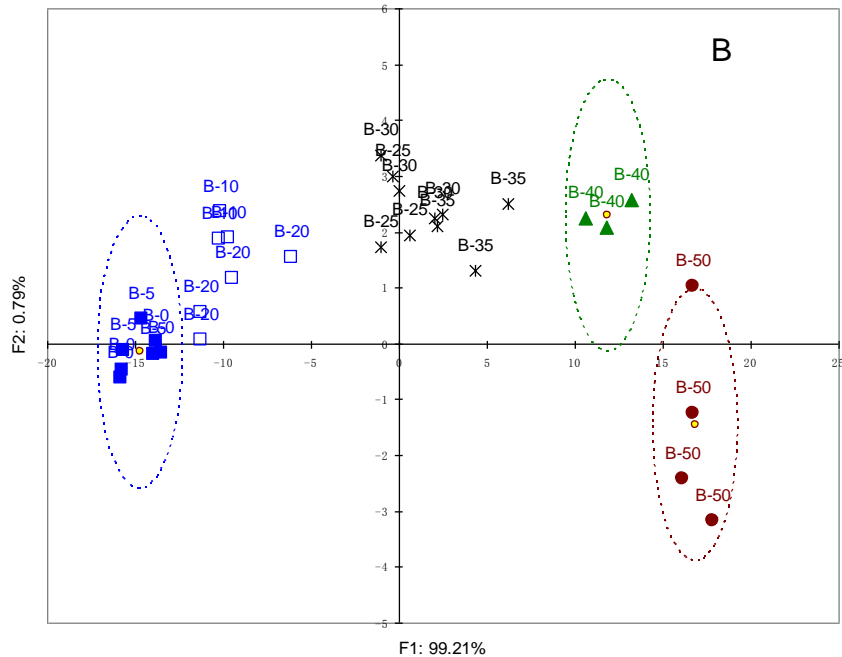
$$\sum_{d_1}^{d_2} (R \cdot \Delta t) = \alpha \cdot \sum_{d_1}^{d_2} (T_d - T_t) \cdot \Delta t$$

The accumulation of $(T_d - T_t)$ from d_1 to d_2 is thermal time, when $(T_d - T_t < 0)$,

$T_d - T_t = 0$, (Unit: degree • Day), It is the chemical decreased by weight of $(T_d - T_t)$

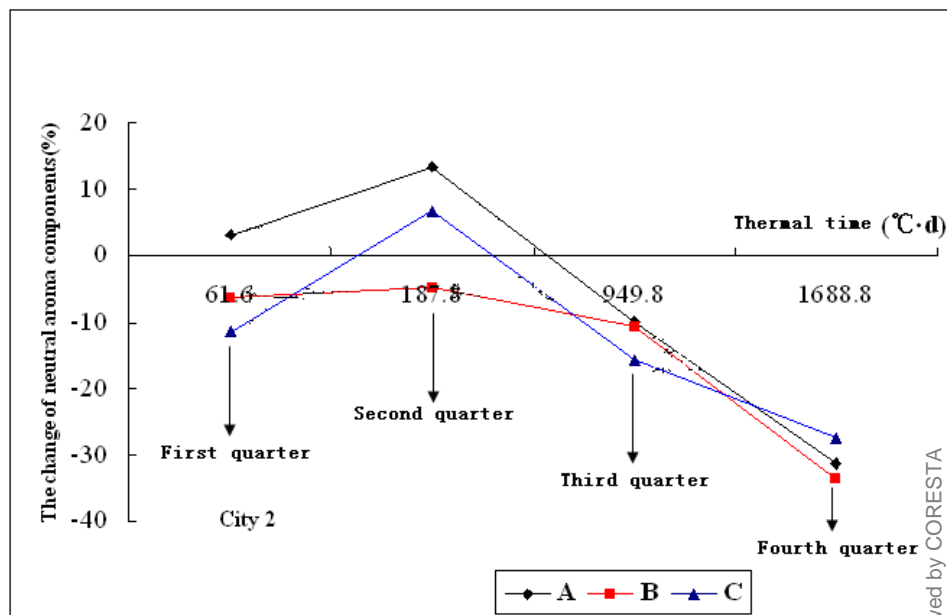
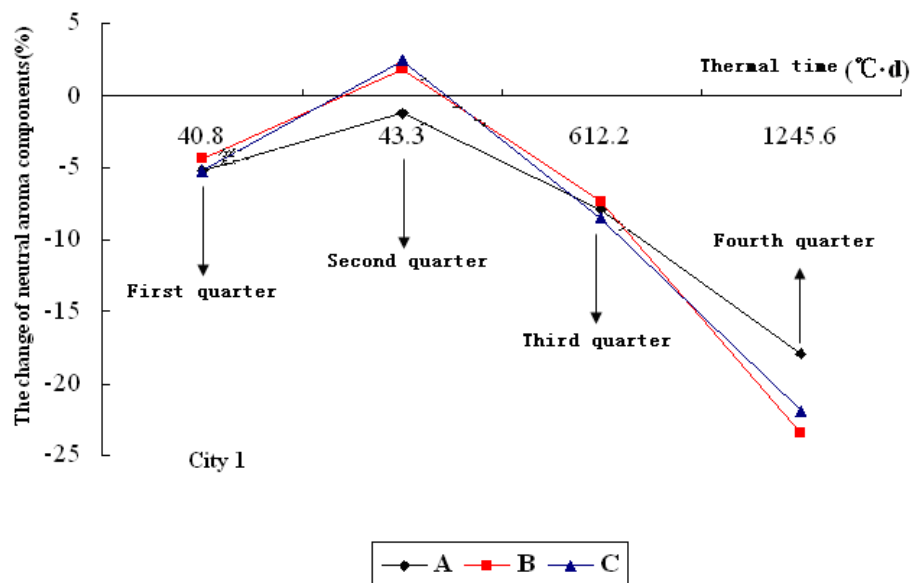
Samples (Tem. Seq.)

- A
- B (From -5°C to 50 °C at 5 °C/seq.)
- C



20-30°C was the initial temperature range wherein the total contents of volatile components in cigarette began to decrease.

Thermal times regression: y-neutral aroma components x-thermal times



two cities

Sensory Evaluation: Triangle-test

Objects &
time seq.

7 objects: one color block one objects

6 cities: one y-grid one city

Total 42 samples

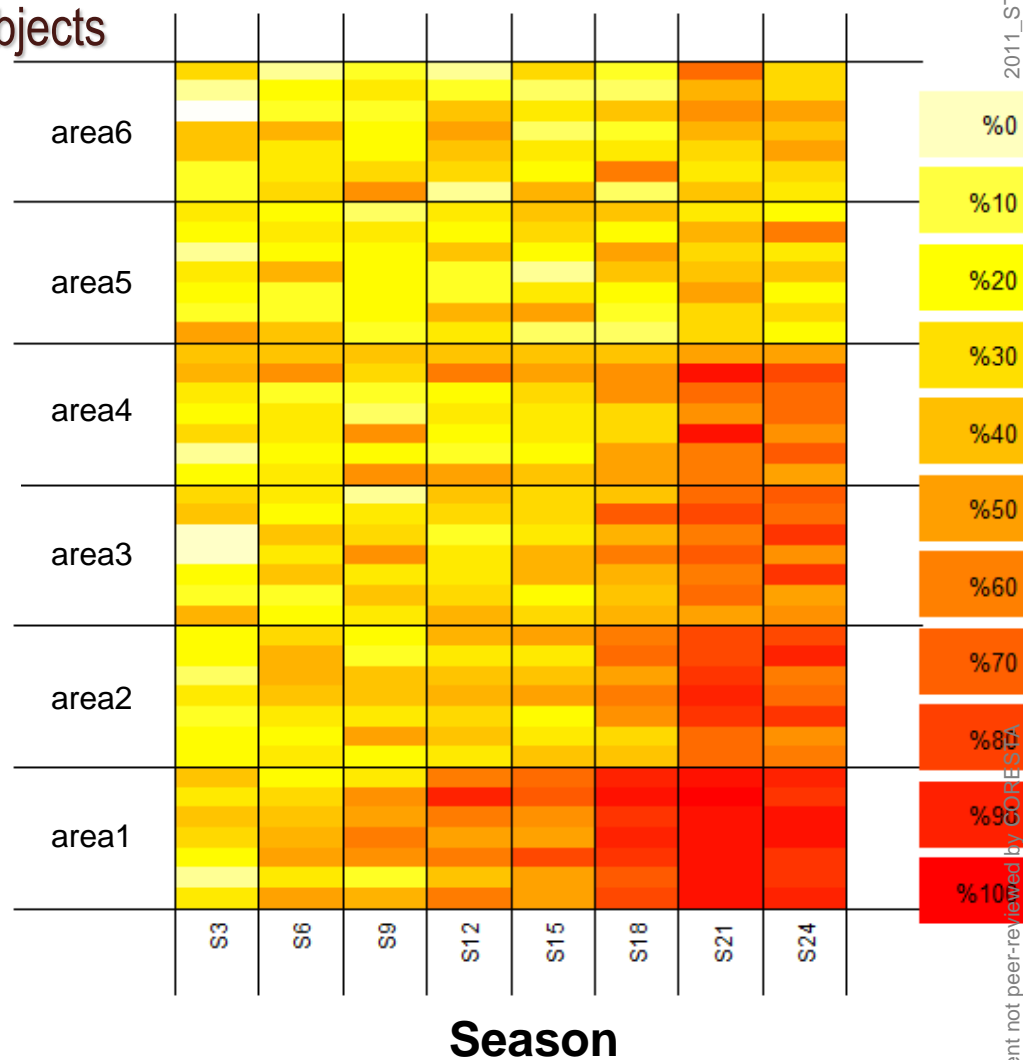
S3~S24: one x-grid one season

Total two years

Panels &
colour id.

The samples were compared with standards by panels of experts every three months. The results of triangle method showed in this heat plot, the identical color of comparison from white to red, indicated the differences from small to large as times goes by.

area



Generalized Linear Models of sensory evaluation

Differences binomial test~Storage time+Temperature+Moisture

Coefficiat:

Constant	Storage Time	Tem.	Mois.
-8.34293	0.76092	0.10000	0.03553

df: 335/332

AIC: 280.4

Significant(p-value<0.004)

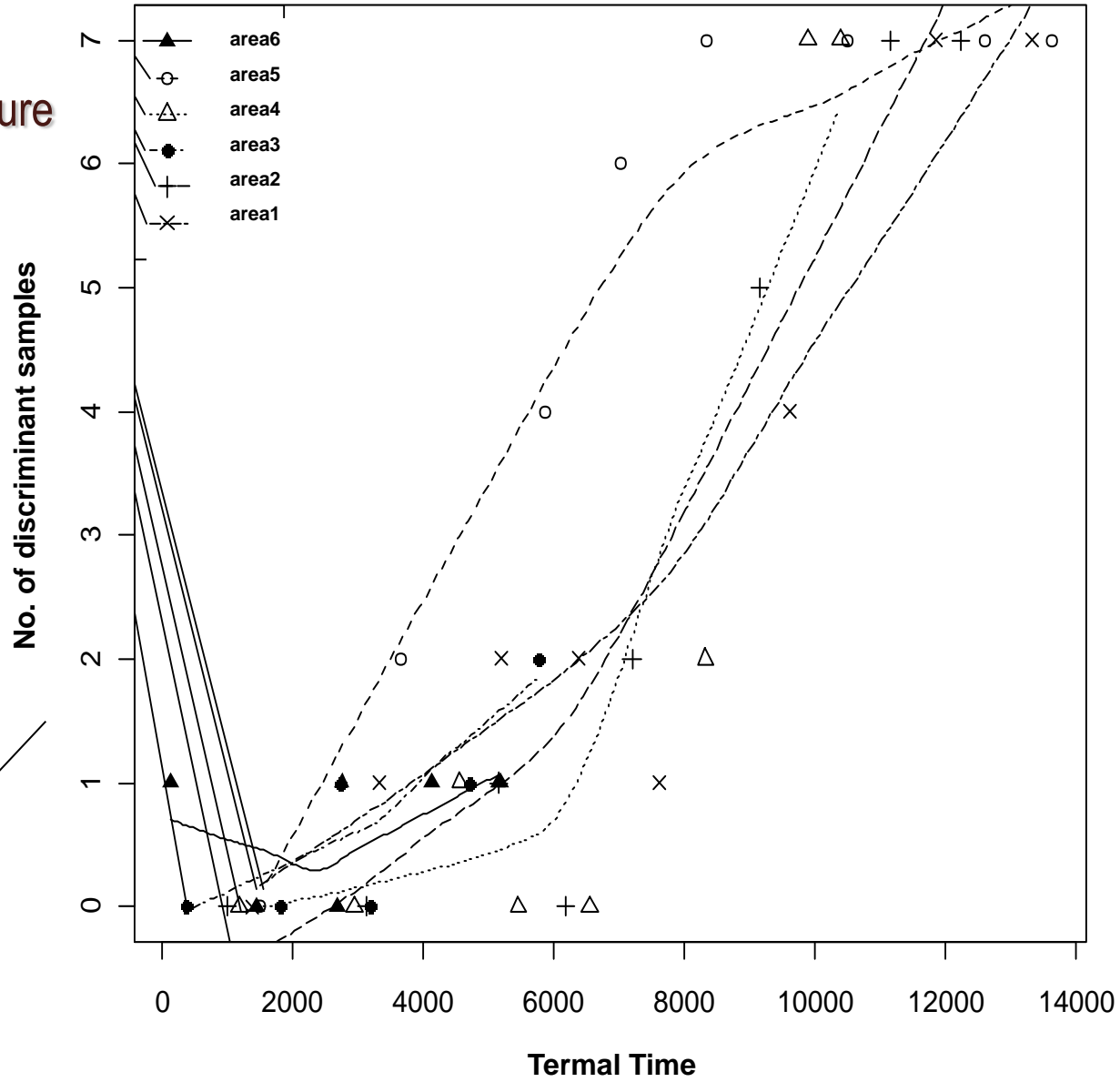


Thermal times Model of sensory evaluation

area 1 & 6:
north cities with low temperature

area 2, 3, 4, 5:
Cities with high temperature

Windows linear fitting



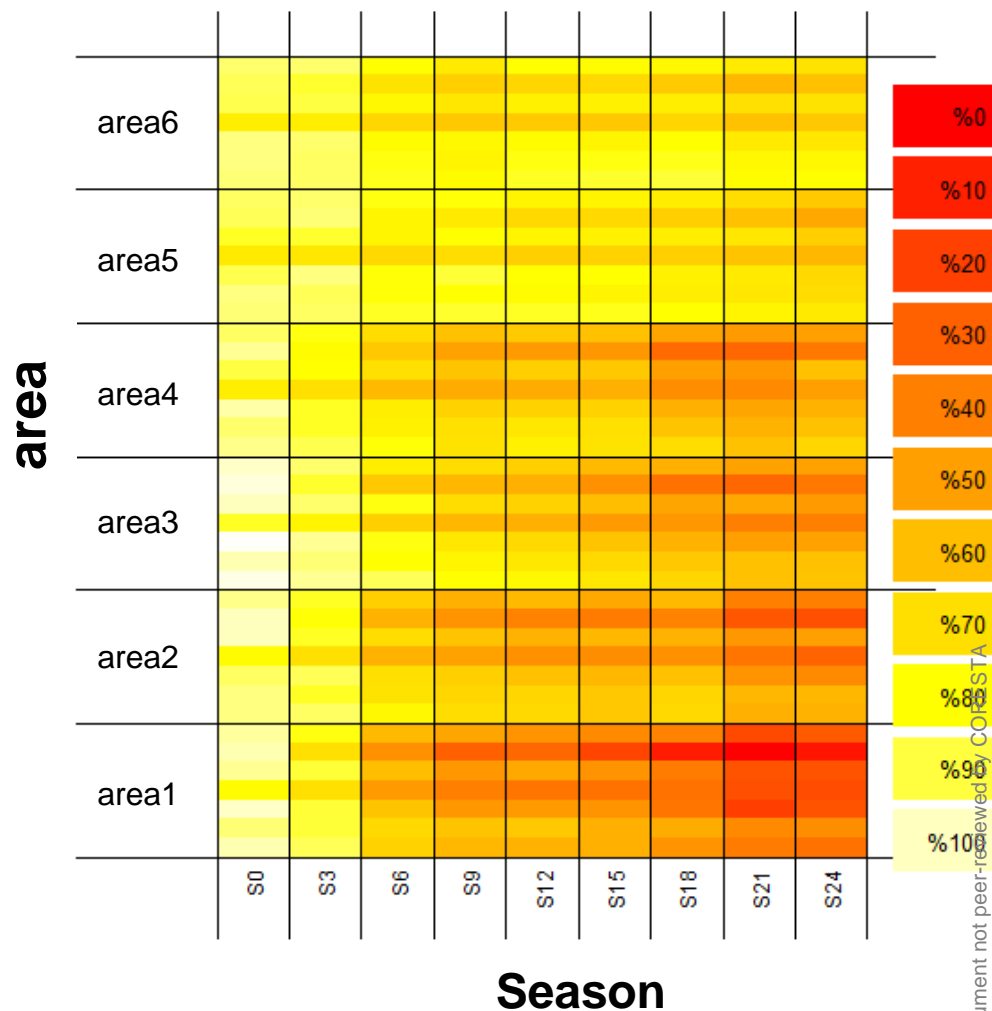
Linear Models of brightness - cigarettes paper

Objects & time seq. {

- 7 objects: one color block one objects
- 6 cities: one y-grid one city
- Total 42 samples
- S3~S24: one x-grid one season
- Total two years

Brightness detect & color id. {

- Every season, the brightness was detected, the white paper from white to yellow and grey, and the identical color from white to red.



Linear Models of Brightness

Brightness~ Season + Tem + Hum,data=sensory

Residuals:

Min	1Q	Median	3Q	Max
-11.3027	-1.9655	0.1769	2.1620	8.2801

Coefficients:

Estimate	Std. Error	t value	Pr(> t)
(Intercept)	90.78342	110.386	< 2e-16 ***
Season	-1.19217	-15.175	< 2e-16 ***
Tem	-0.19011	-8.227	4.42e-15 ***
Hum	-0.04098	-2.791	0.00555 **

Signif. codes: 0 '***'. 0.001 '**'. 0.01 '*'. 0.05 '.' 0

Residual standard error: 3.285 on 332 degrees of freedom

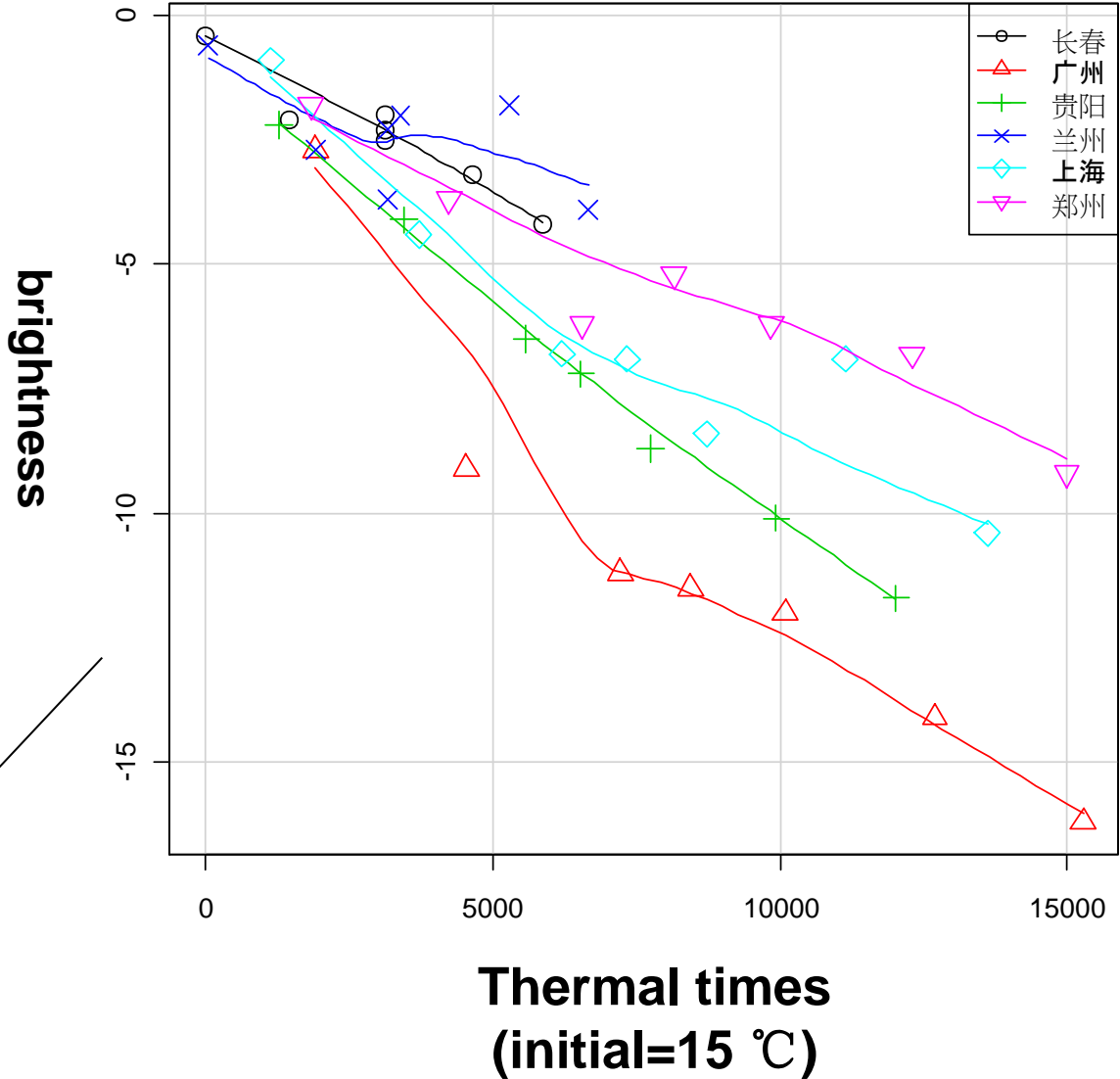
Multiple R²: 0.4997

Adjusted R²: 0.4952

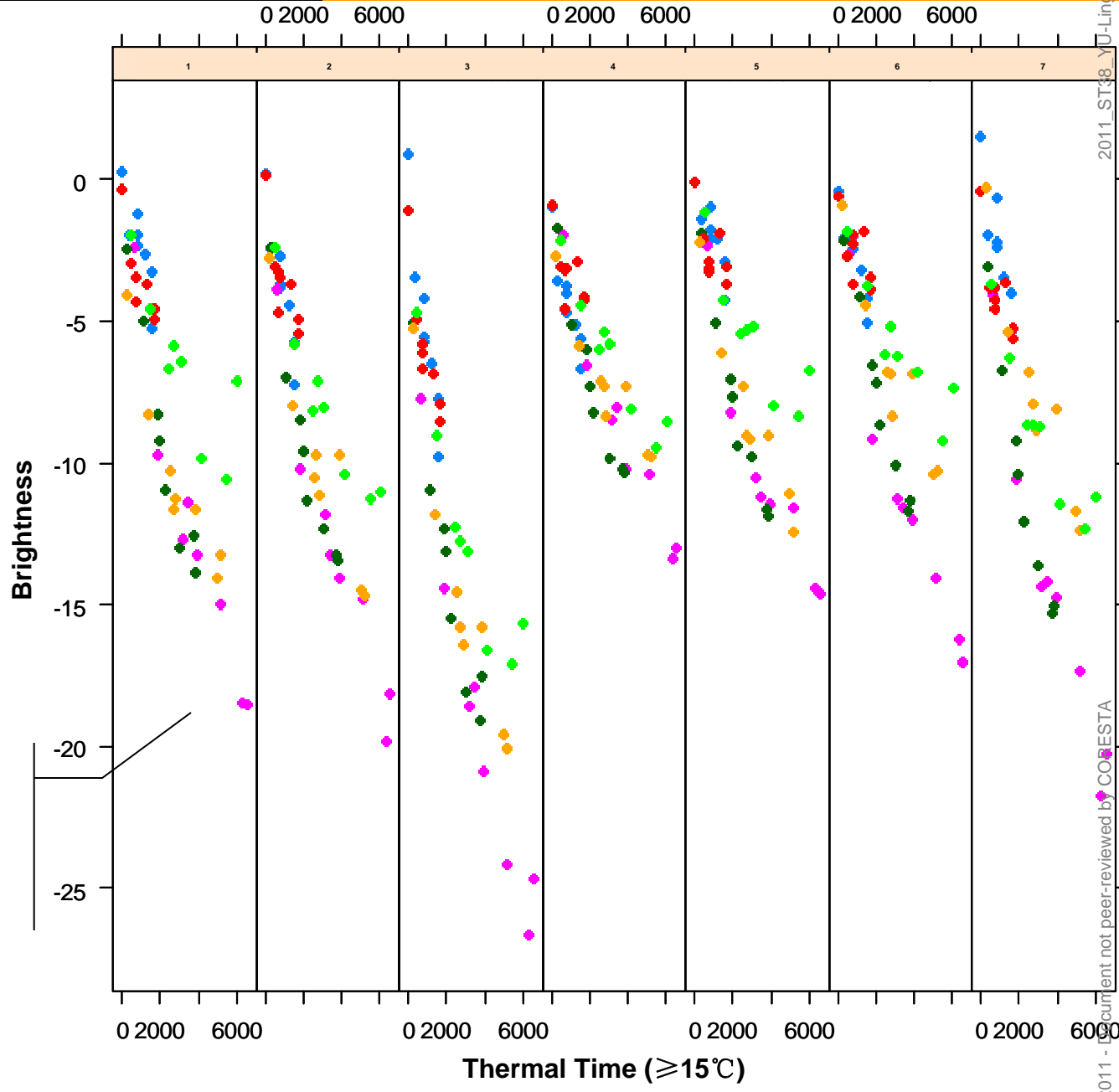
F-statistic: 110.5 on 3 and 332 DF, p-value: < 2.2e-16

Thermal times Models of six cities

**Windows
linear fitting**



Seven brands stored in six cities



Part 4

Conculsion

The quality of cigarettes is changed by the storage time goes by, including chemistry in tobacco cut, appearance of cigarettes, especially the sensory of products.

Storage condition like high temperature and high moisture is not good for the quality. Suitable temperature is no more than 28°C and moisture from 40% to 70%.

Part 5 Acknowledgements

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Thank you!

