# Korean Rice Distilled Spirits (Soju) Maturation

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## INOTRODUCTION

Traditionally Korean pot distilled Soju was not a long term matured spirit. 3 to 6 month was enough at the longest. 'Storage' can be more correct term than 'maturation'. In many industry cases, over production of Soju is over stock, they take an unwanted extra cost for storage. On the contrary, Whisky and Brandy must be matured, the period of maturation gives more value. The maturation study of Soju can be suggested as a way to be a premium alcoholic beverage. Also in a long-term point of view, it can greatly contribute to the supply and demand conditions of rice (strategy of agricultural product in Korea).

3 different materials were prepared for maturing the new make spirit (Soju), which were oak wood (American white oak; Quercus alba), ceramic and stainless containers. The size of all containers was 20 litres capacity. The oak wood casks were new made with medium toasting and imported from a Spanish cooperage. Onggi(Ceramic) containers were made by Korean Onggi master. Stainless containers were 20 litres standard size with a closing end.

The maturation study will be consist of various tracking analysis, which are flavour compounds, physico-chemistry change, optical analysis and alcohol-water molecular bonding strength.

## MATERIALS AND METHODS

### *New-Make Spirits (Soju)*

5,000 litres of new-make soju were manufactured, which were diluted at 43.5%v/v and filled in 3 different containers for maturation at the same time.

**Table 1. Manufacturing manner of new-make Soju**

| | | | | | |
|---|---|---|---|---|---|
| *Process* | *Polishing rice & Cooking* | *Pre Fermentation (Enzyme Source)* | *1st Fermentation* | *2nd Fermentation* | *Batch Distillation (Reduced pressure)* |
| | *Rice 2,000kg* | *Asp.luchuensis (0.05% of Rice)* | *S.Cerevisiae (KFRI 88-4)* | *Rice 4,000kg* | *Wash 15,600ℓ, 18.3%v/v Spirit 5,770ℓ, 46.9%v/v Distillation Rate 95%* |
| *Day+* | *0* | *2* | *7* | *17* | *17* |

### *Materials for Soju maturation*

3 different materials were prepared for the Soju maturation. Each of the experiments has 30 numbers of identical containers to do periodical tracking analysis. 20 litres of new-make Soju were filled in each containers.

**Table 2. Properties of materials for Soju maturation**

| | *Oak Wood (Q.alba)* | *Onggi (Ceramic)* | *Stainless* |
|---|---|---|---|
| *Image* |  |  |  |
| *Capacity (ℓ)* | *20* | *20* | *20* |
| *Height (㎝)* | *46* | *50* | *40* |
| *Width (㎝)* | *30* | *30* | *35* |
| *Weight (㎏)* | *6.1±0.5* | *10.9±0.5* | *3.3±0.1* |

### *Tracking Anaysis of Soju maturation*

Diverse analysis were performed to find out the differences of maturation materials.

**Table 3. Analytical methods for tracking of maturation**

| | *Analysis* | | *Unit* |
|---|---|---|---|
| *General* | *Warehousing* | *Temperature* | *℃* |
| | | *Relative Humidity* | *%RH* |
| | *Alcohol* | | *%v/v* |
| | *pH* | | *-* |
| | *Conductivity* | | *㎲* |
| *Optical* | *Colour* | *L(lightness)* | *-* |
| | | *a(+red, -green)* | |
| | | *b(+yellow, -blue)* | |
| | *Absorbance* | *OD 275 nm* | *-* |
| | *Turbidity* | *NTU* | *-* |
| *Components* | *Flavours (GC/MS)* | *C2 ~ C7* | *% Area* |
| | | *C8 ~ C20* | |
| | *Fusels (GC/FID)* | *i-amylalcohol* | *㎎/ℓ* |
| | | *i-butylalcohol* | |
| | *Minerals (ICP)* | *Na* | *㎎/㎏* |
| | | *K* | |
| | | *Ca* | |
| | | *Mg* | |
| | | *Fe* | |
| | | *Si* | |
| *Molecular* | *NMR–O17* | *Half peak width size* | *㎐* |
| | *DSC* | *-60~0℃* | *kJ* |

## RESULTS

Just 9 months of maturation period changed many analytical properties of the spirits. The maturation materials reflected the characteristics on the spirits. Through the maturation study, the possibility of potentially diverse Soju products was discovered.

### General Analysis

Different container's material has been showing different maturation performances.
(At present the 9 months periodical experiment on progress).

**Figure 1. Temperature and Relative Humidity Change during warehousing period (9 months tracking)**

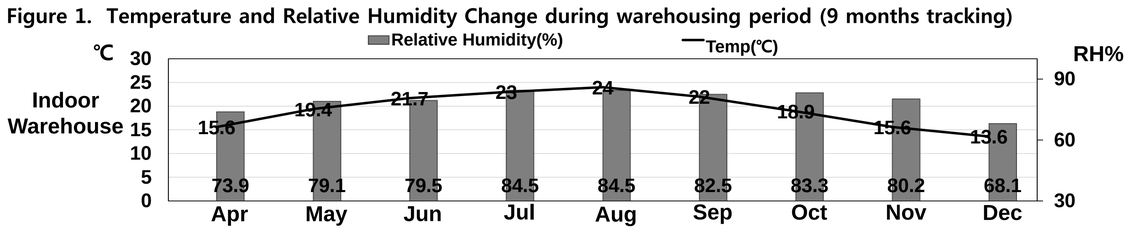



**Figure 2. Volume Loss**

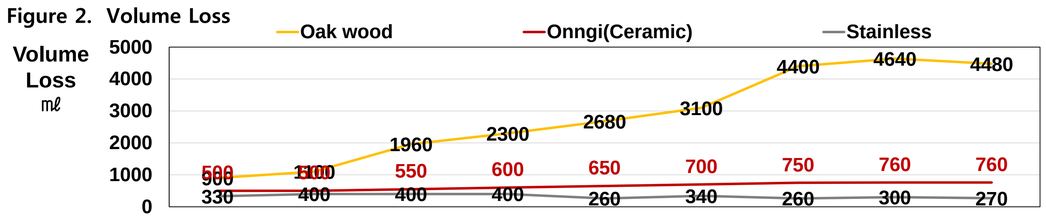



**Figure 3. Decreasing of Alcohol Strength**

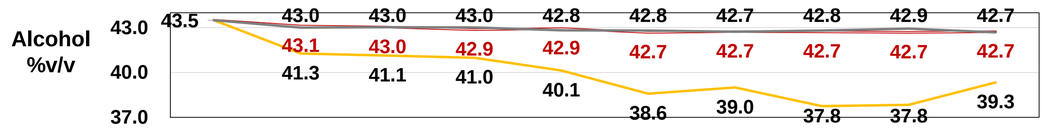



**Figure 4. pH Changes**

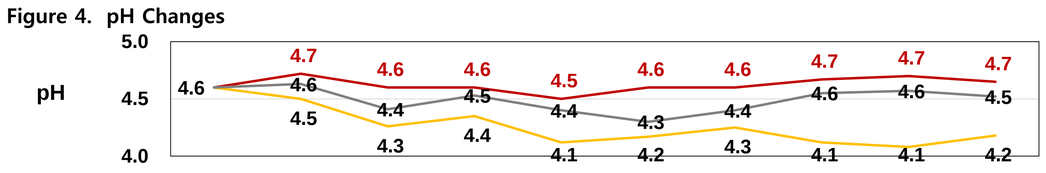
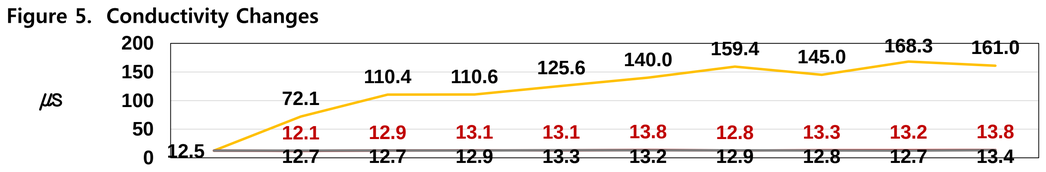



**Figure 5. Conductivity Changes**




### Optical Analysis

The Oak wood maturation has been changes more than other cases. The optical analysis(Initial and 9 month) values are shown in the table 4 below.

**Table 4. Optical Analysis Changes**

| Optical Analysis | Colour | | | | | | | | | Absorbance | | | Turbidity | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | L (lightness) | | | a (+red, -green) | | | b (+yellow, -blue) | | | OD 275nm | | | NTU | | |
| | Initial | 9 month | △ | Initial | 9 month | △ | Initial | 9 month | △ | Initial | 9 month | △ | Initial | 9 month | △ |
| Oak Wood | 100.0 | 90.3 | - 9.7 | 0.0 | - 0.4 | - 0.4 | 0.0 | 36.7 | 36.7 | -0.031 | 0.974 | 1.005 | 0.140 | 2.250 | 2.110 |
| Onggi | | 100.0 | - | | 0.0 | - | | 0.0 | - | | -0.026 | 0.005 | | 0.071 | -0.069 |
| Stainless | | 100.0 | - | | 0.0 | - | | 0.0 | - | | 0.017 | 0.048 | | 0.092 | -0.048 |

### Components Analysis

Heavier carbon compounds(C8~C20) were increased in all cases. For fusels, 2 dominant flavour compounds were i-amylalcohol and i-butanol. Each of A/B ratios changed differently. After 9 months maturation, minerals were also detected.

**Table 5. Carbon compounds Changes**

| GC/MS (% area value of alcohol relative comparison) | | | | | | |
|---|---|---|---|---|---|---|
| Number of Carbons | C2~C7 | | C8~C20 | | Total | |
| | Initial | 9 month | Initial | 9 month | Initial | 9 month |
| Oak Wood | 1.339 | 1.369 | 0.100 | 1.156 | 1.439 | 2.525 |
| Onggi | | 1.411 | | 1.588 | | 2.999 |
| Stainless | | 1.339 | | 1.600 | | 2.939 |

**Table 6. Fusels and A/B Ratio Changes**

| GC/FID (A: i-amylalcohol, B: i-butylalcohol) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Fusels (㎎/ℓ) | A | | | B | | | A/B Ratio | | |
| | Initial | 9 month | △ | Initial | 9 month | △ | Initial | 9 month | △ |
| Oak Wood | 265.9 | 322.2 | 56.3 | 122.1 | 124.0 | 1.9 | 2.2 | 2.6 | 0.4 |
| Onggi | | 358.2 | 92.3 | | 99.8 | - 22.3 | | 3.6 | 1.4 |
| Stainless | | 303.1 | 37.2 | | 104.6 | - 17.5 | | 2.9 | 0.7 |

**Table 7. Minerals**

| Mineral contents in 9 months maturation | | | | | | | |
|---|---|---|---|---|---|---|---|
| ㎎/㎏ | Na | K | Ca | Mg | Fe | Si | Total |
| Oak Wood | 24.30 | 24.27 | 9.97 | 1.79 | <0.07 | 1.66 | 61.99 |
| Onggi | 15.98 | <0.02 | 5.05 | 0.51 | <0.07 | 1.47 | 23.01 |
| Stainless | 15.70 | <0.02 | 5.30 | 0.49 | <0.07 | 1.50 | 22.99 |

### Molecular Bonding

All the experiments showed a similar tendency. The increasing of heat of fusion and the decreasing half peak width size of NMR suggest that the molecular bonding of alcohol-water has been strengthened during maturation.

**Table 8. DSC and NMR Analysis**

| Alcohol-Water Molecular Bonding | | | | | | |
|---|---|---|---|---|---|---|
| | DSC (J/g) | | | NMR $O^{17}$ (㎐) | | |
| | Initial | 9 month | △ | Initial | 9 month | △ |
| Oak Wood | 33.8 | 58.6 | 24.8 | 160.8 | 146.5 | - 14.3 |
| Onggi | | 58.0 | 24.2 | | 151.1 | - 9.7 |
| Stainless | | 54.3 | 20.5 | | 150.5 | - 10.3 |

## CONCLUSIONS AND DISCUSSIONS

- ◆ Using identical New-make "Soju", but totally different properties in maturation
- ◆ Maturation materials can lead new-make spirits to diverse matured spirits
- ◆ Oak wood maturation has dramatic changes in comparing with other materials
- ◆ Onggi(Ceramic) maturation showed increasing of pH, Minerals, and Molecular bonding (DSC, NMR)
- ◆ Stainless maturation is good for storing in purpose with unchanging of spirits

## FUTURE WORK

Maturation study will go on until May 2017 (3 years maturation period)
Usability study of diverse Onggies and Woods varieties for Soju maturation

## ACKNOWLEDGEMENT

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