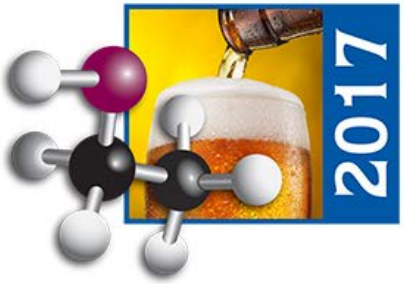


ASBC Annual Meeting
June 4–7 ■ Fort Myers, Florida
See what SCIENCE can brew for you

Influence of high temperature exposure during transportation on beer flavor

Research Laboratories for Alcohol Beverages
ASAHI BREWERIES, Ltd.

Tomoko Koyano, Kaori Kikuchi, Minoru Kobayashi, Tetsuya Watanabe

Asahi

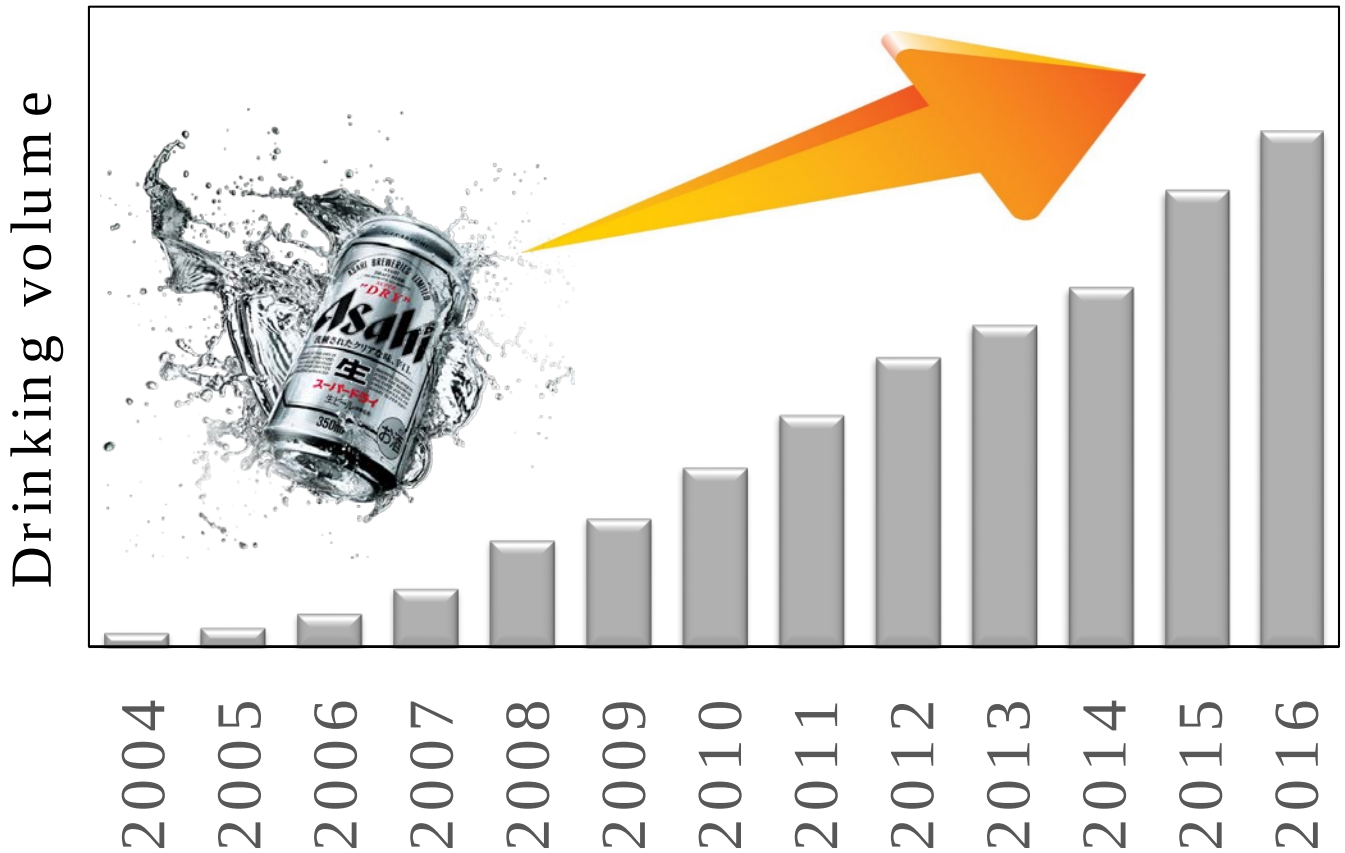
ASAHI “SUPER DRY”

- No. 1 beer in the Japanese market
- “Karakuchi” taste: refreshingly crisp, clear taste
- Continuing to improve the taste

“SUPER DRY” is consumed worldwide

Drinking volume overseas are increasing

Drinking volume change in country A



Severe environments in overseas transport

✓ Long distance

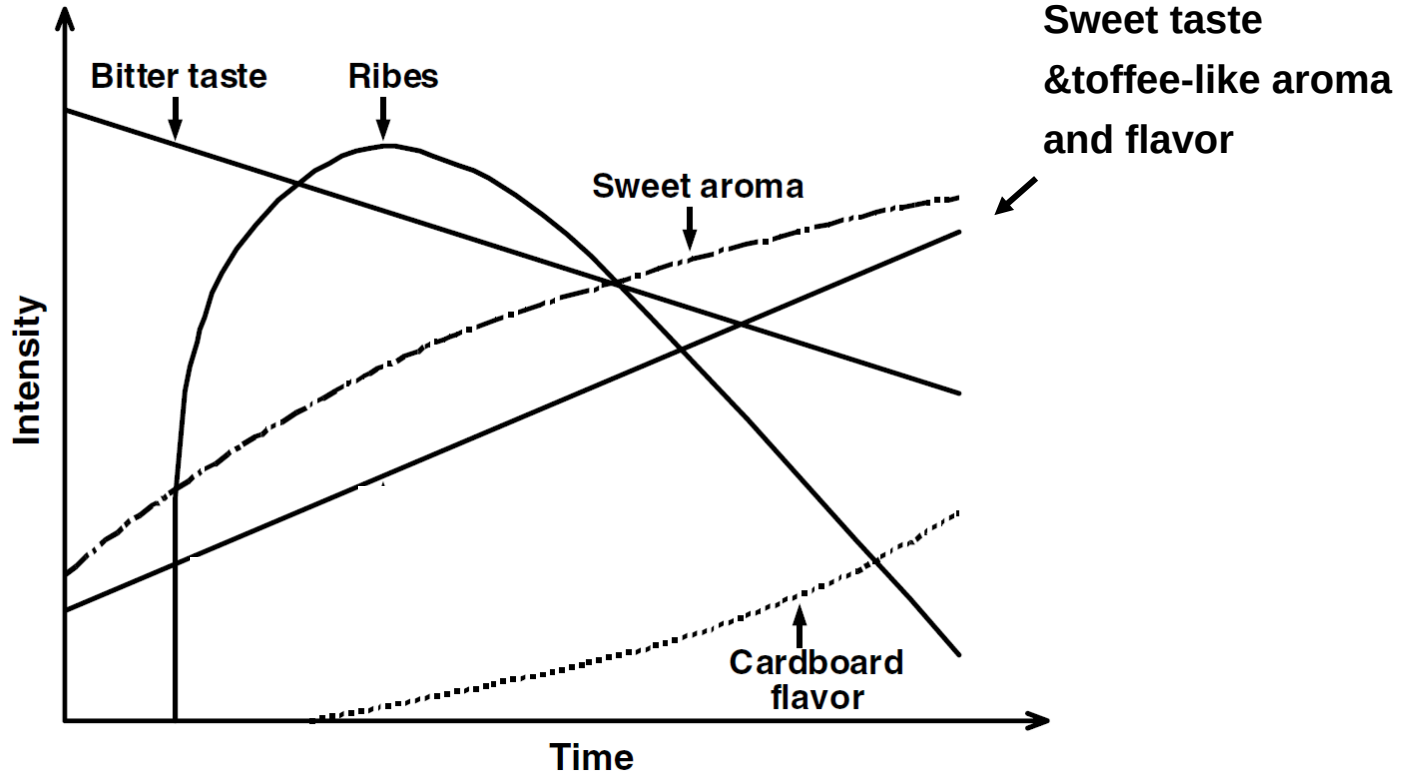
✓ Long periods

✓ Various means

(Land /Marine…)

Sensory changes during beer storage

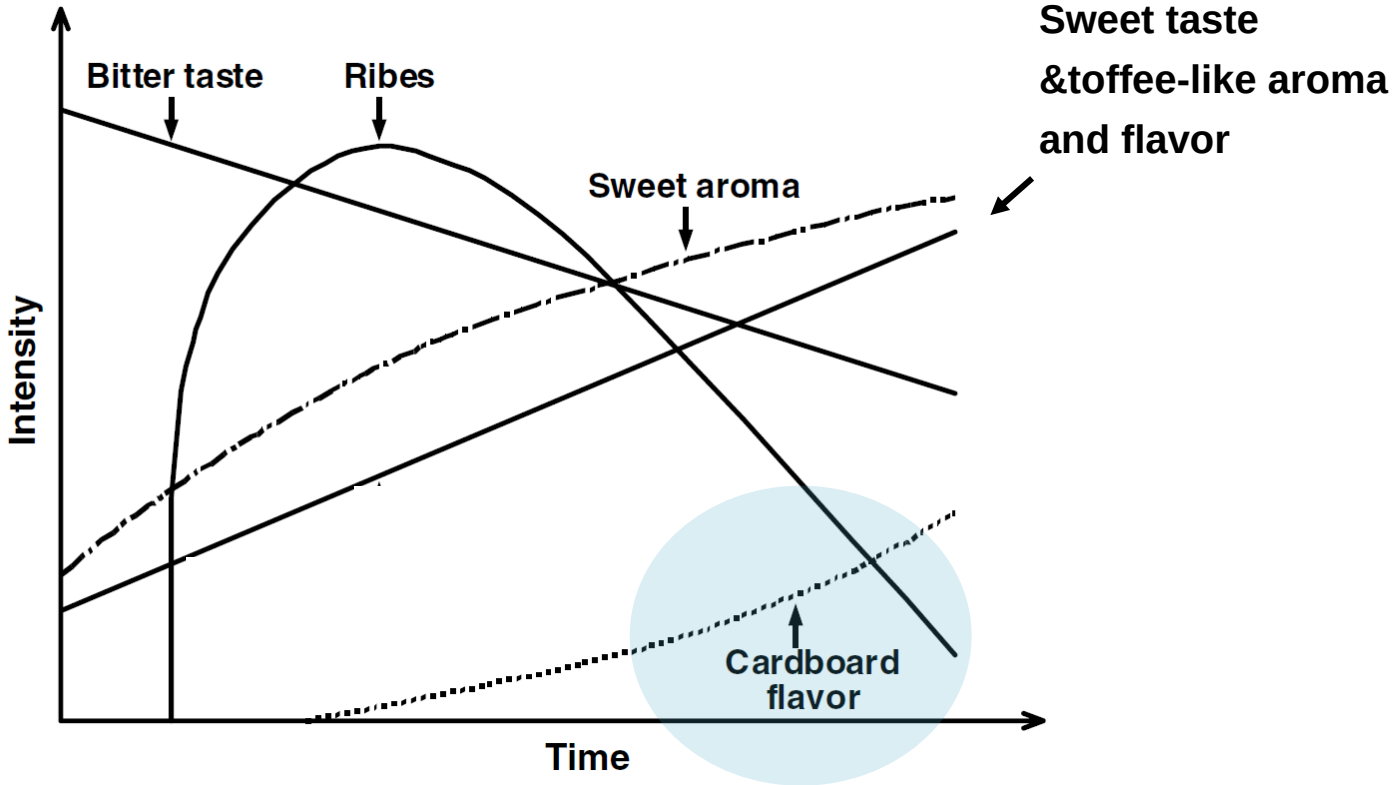
- ✓ Constant increase in cardboard flavor
- ✓ Sweet aroma development
- ✓ Constant decrease in bitterness



Dalgliesh, C.E.et al., EBC, Proceedings of the EBC Congress,623-659 1977.

Domestic transport

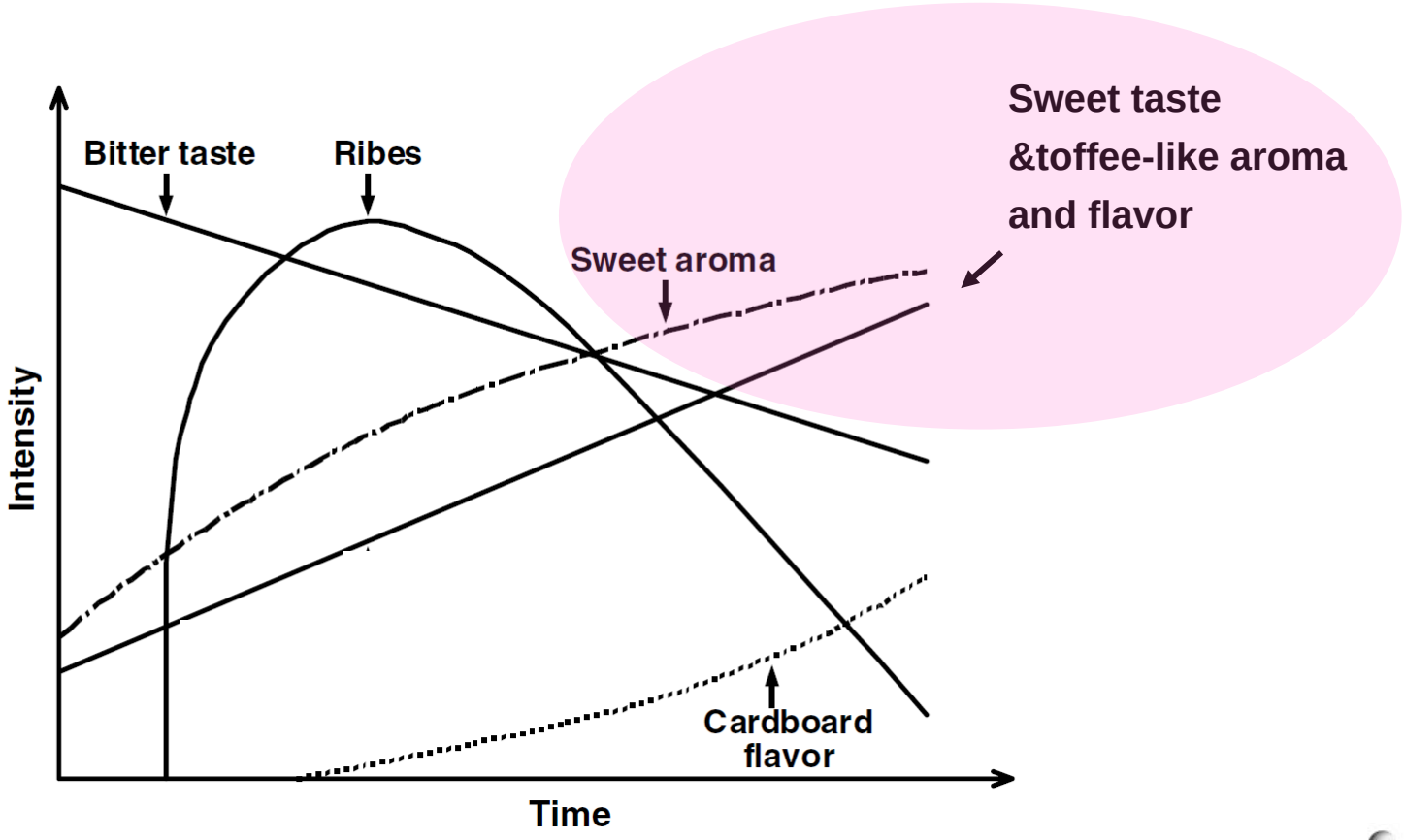
- ✓ Constant increase in cardboard flavor
- ✓ Increase in sweet aroma
- ✓ Reduction in bitterness



Dalgliesh, C.E.et al., EBC, Proceedings of the EBC Congress,623-659 1977.

Overseas transport

Does deterioration progress more and the sweet aroma increase?



Dalgliesh, C.E.et al., EBC, Proceedings of the EBC Congress,623-659 1977.

Sensory evaluation of transported beers

transport

How does it taste?

9 months after manufacturing	6 months after manufacturing	4 months after manufacturing
Aging 3 Cardboard3 **Sherry2** **Soy sauce** **Sweet** **Miso** Sticky Smokey Pickles	**Soy sauce2** **Aging 2** Cardboard2 **Sherry** **Sweet2** **Miso** **Candy** Sticky Air oxidation Watery Pickles Astringency	**Aging 5** Cardboard2 Smokey Skunky Pickles

※5 Panellists

Sensory evaluation of transported beers

transport

How does it taste?

9 months after	6 months after	4 months after
Sherry2□Soy sauce□Sweet□ Miso□Sticky□ Smokey□Pickles	**Sherry□Sweet2□ Miso□Candy□** Sticky□Air oxidation□ Watery□Pickles□ Astringency	Cardboard2□ Smokey□Skunky□ Pickles

We express these sweet aroma increasing during transport overseas as “aging flavor”

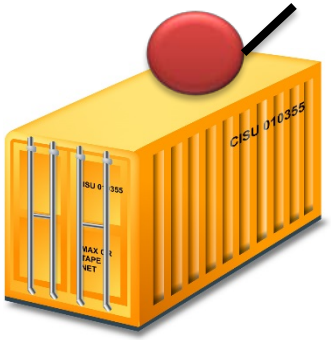
※5 Panellists

Research objective

- **Understand the processes occurring during overseas shipment.**
- **Establish effective technologies for overseas transport to improve flavor stability.**

Temperature history survey during transport

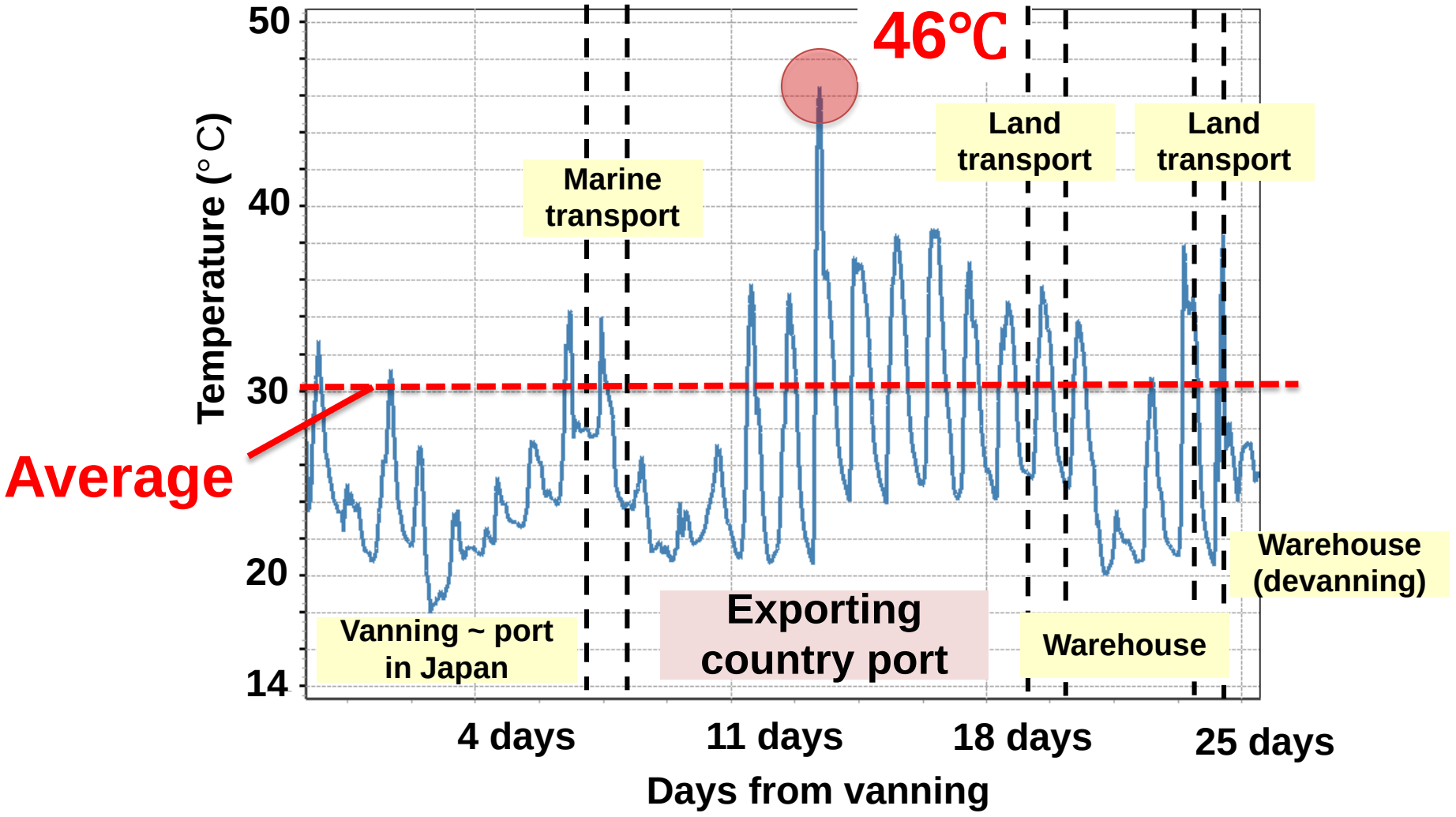
Temperature history logger



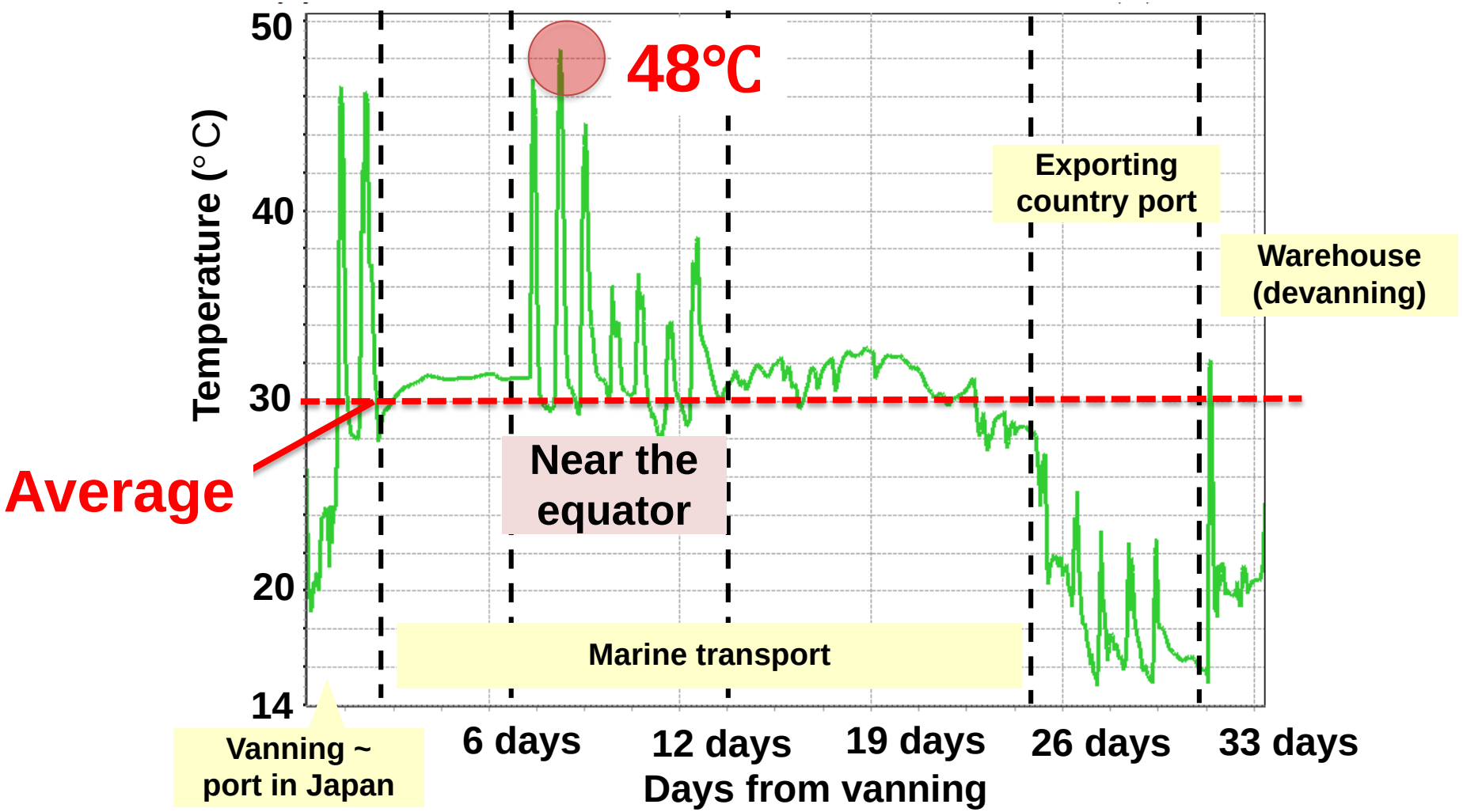
Pattern A
- Transport period:25 days

Pattern B
- Transport period:30 days
- Pass through the equator

Pattern A: Temperature history survey results



Pattern B: Temperature history survey results



Sensory evaluation of transported beers

transport

How does it taste?

9 months after	6 months after	4 months after
	Astringency	

We express these sweet aroma increasing during transport overseas as “aging flavor”

Which compounds affect the aging flavor of products shipped overseas?

※5 Panellists

Research scheme

1. Target analysis of components reported to be indicators of aging flavor.

2. Search for new indicators by multivariate analysis.

3. Confirm that the new candidate compounds affect the aging flavor.

Research scheme

1. Target analysis of components reported to be indicators of aging flavor.
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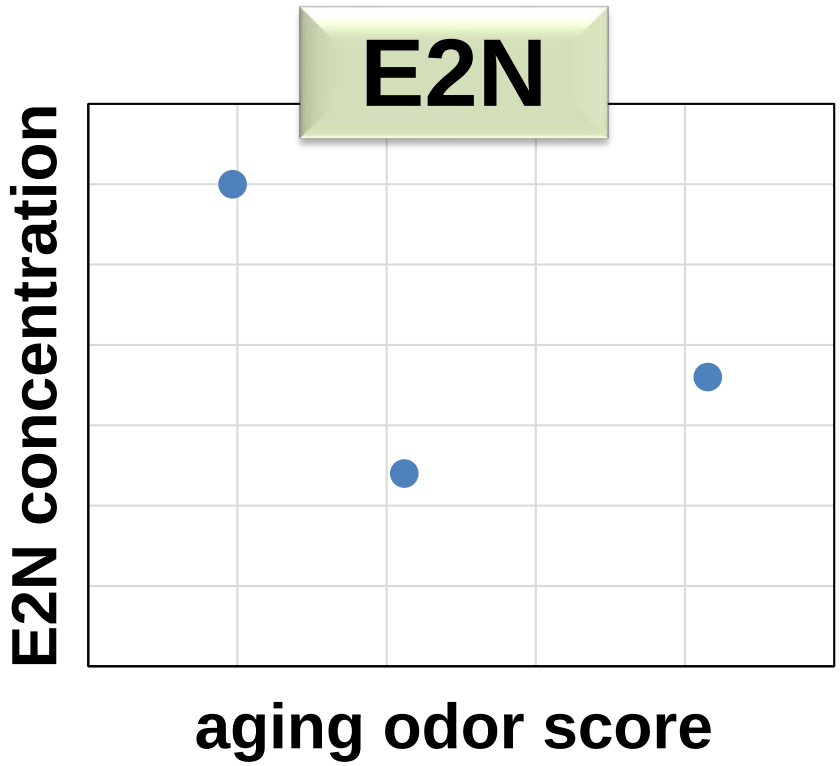
Analysis for candidate components



- Candidate components at 25° C storage in our products.
  - (E)-2-nonenal
  - γ-nonalactone
  - dimethyltrisulfide
  - 3-methylthiopropionaldehyde
  - (E)-β-damascenone
  - ethyl 2-methylpropionate
  - ethyl 2-methylbutyrate
  - sotolon
  - 3-methyl-2-butene-1-thiol

(Wanikawa, A., et al. 71st Annual Meeting of ASBC, 2007)

Future plan

1. Target analysis of components reported to be indicators of aging flavor.

2. Search for new indicators by multivariate analysis.

3. Confirm that the new candidate compounds affect the aging flavor.

Search for new candidate components

Samples

- Transported overseas
- Stored at high temperature

Sensory evaluation

Description method

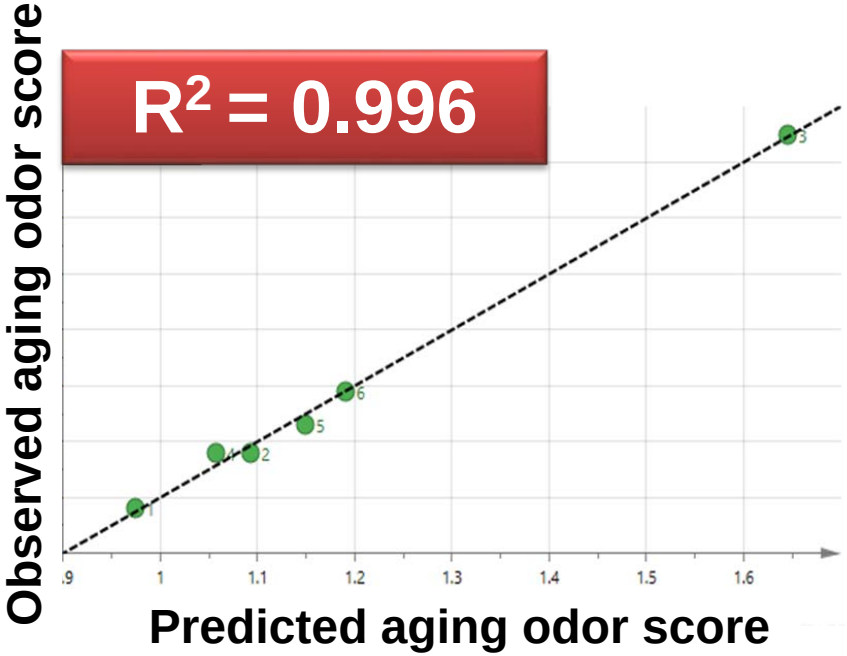
Non-targeted analysis

GC/MS

Search for new candidate components

PLS regression analysis

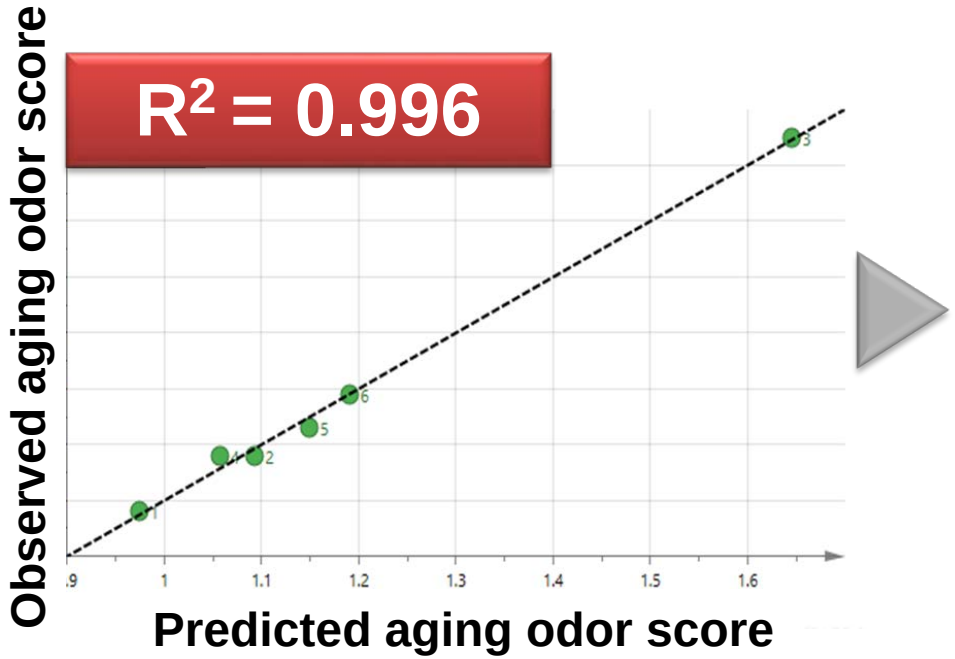
A regression method commonly used to examine the relationship between X variables and Y variables of multivariate data.

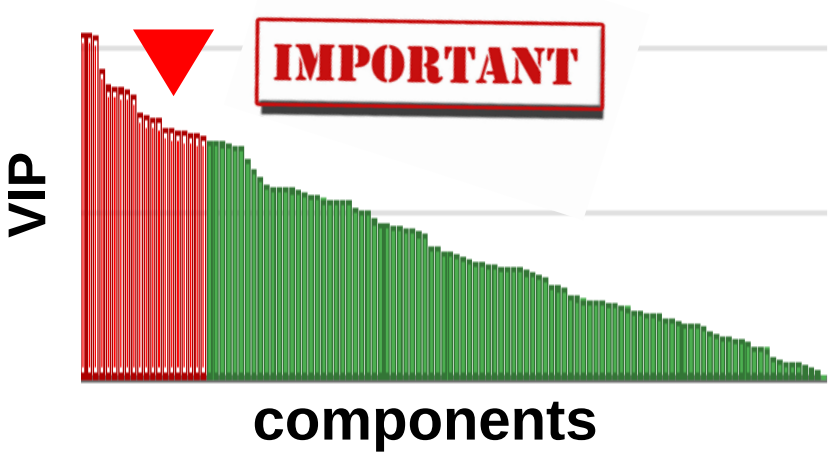


Search for new candidate components

PLS regression analysis
A regression method commonly used to examine the relationship between X variables and Y variables of multivariate data.

VIP: variable importance in the projection





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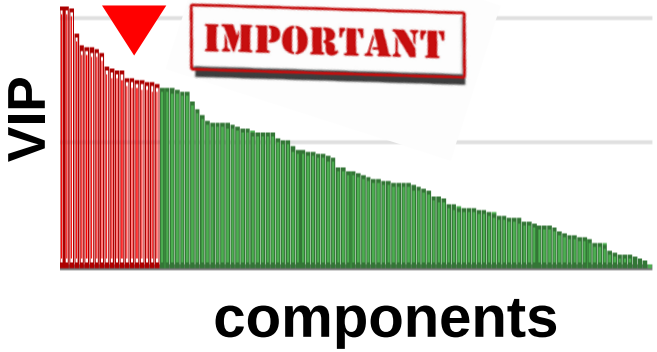
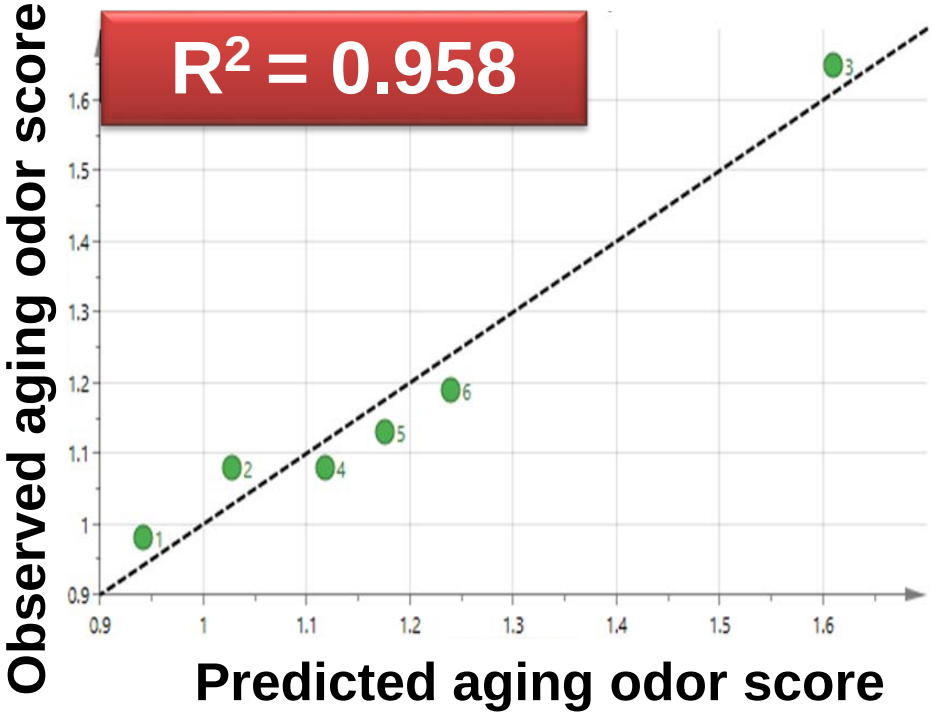
Search for new candidate components

Only 15 selected components can predict aging flavor

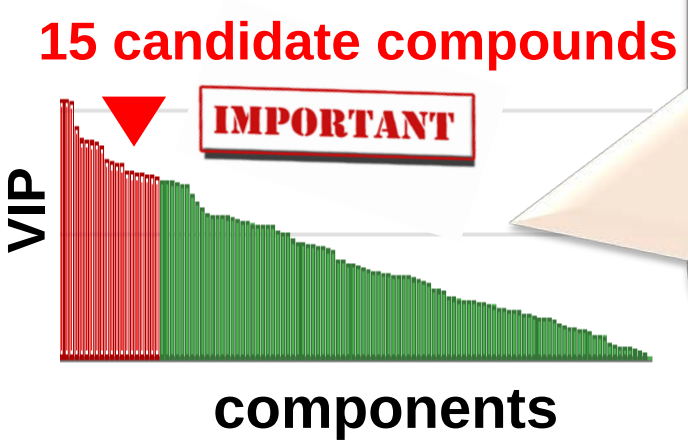
15 candidate compounds





Search for new candidate components

Furfural and 5HMF may be sensitive indicators of aging flavor of products shipped overseas.



Candidate compound	VIP
furfural	1.27
Vanillin	1.25
5-Hydroxymethylfurfural (5HMF)	1.24

Research scheme

1

Target analysis of components reported to be indicators of aging flavor.

2

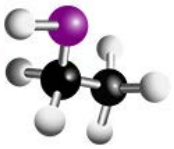
Search for new indicators by multivariate analysis.

3

Confirm that the new candidate compounds affect the aging flavor.

Short summary 1

- Beers transported overseas were characterized by a sweet aroma which we expressed as "aging flavor" .
- During overseas shipment, products were exposed to high temperature.
- Furfural and 5HMF may be indicators of aging flavor in products exported overseas.



Research objective

- Understand the processes occurring during overseas shipment.
- **Establish effective technologies for overseas transport to improve flavor stability.**

Technology for improving flavor stability

The factors…

- **Dissolved oxygen (DO)**
- **SO_2**
- **Transition metal ions**
- **hop acids etc…**

Selected by

- **Improving flavor stability**
- **Not affecting the plain flavor ?**

Technology for improving flavor stability

The factors…

- **Dissolved oxygen (DO)**
- **SO_2**
- **Transition metal ions**
- **hop acids etc…**

Selected by

- **Improving flavor stability**
- **Not affecting the plain flavor ?**

SO_2

- ✓ SO_2 produced during fermentation by yeasts .

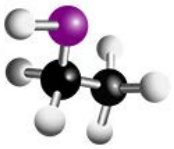
- ✓ SO_2 improves the flavor stability of beer.

(Guido, L. F. et al., Cerevisia,30,137, 132-137, 2005.)

-Radical-scavenging activity

-Bisulfide-carbonyl adducts

There are few reports of practical techniques for controlling SO_2 concentration strictly in brewery.



Steps in evaluating SO_2

STEP 3: Evaluation of factory manufactured beer

Transport manufactured beers overseas

STEP 2: Confirmation of effects at high temperature

Stored beers at 50 ℃.

STEP 1: Establishment of control technique

At the mini brewery (5-kL) and factory (500-kL) scale.

Steps in evaluating SO_2

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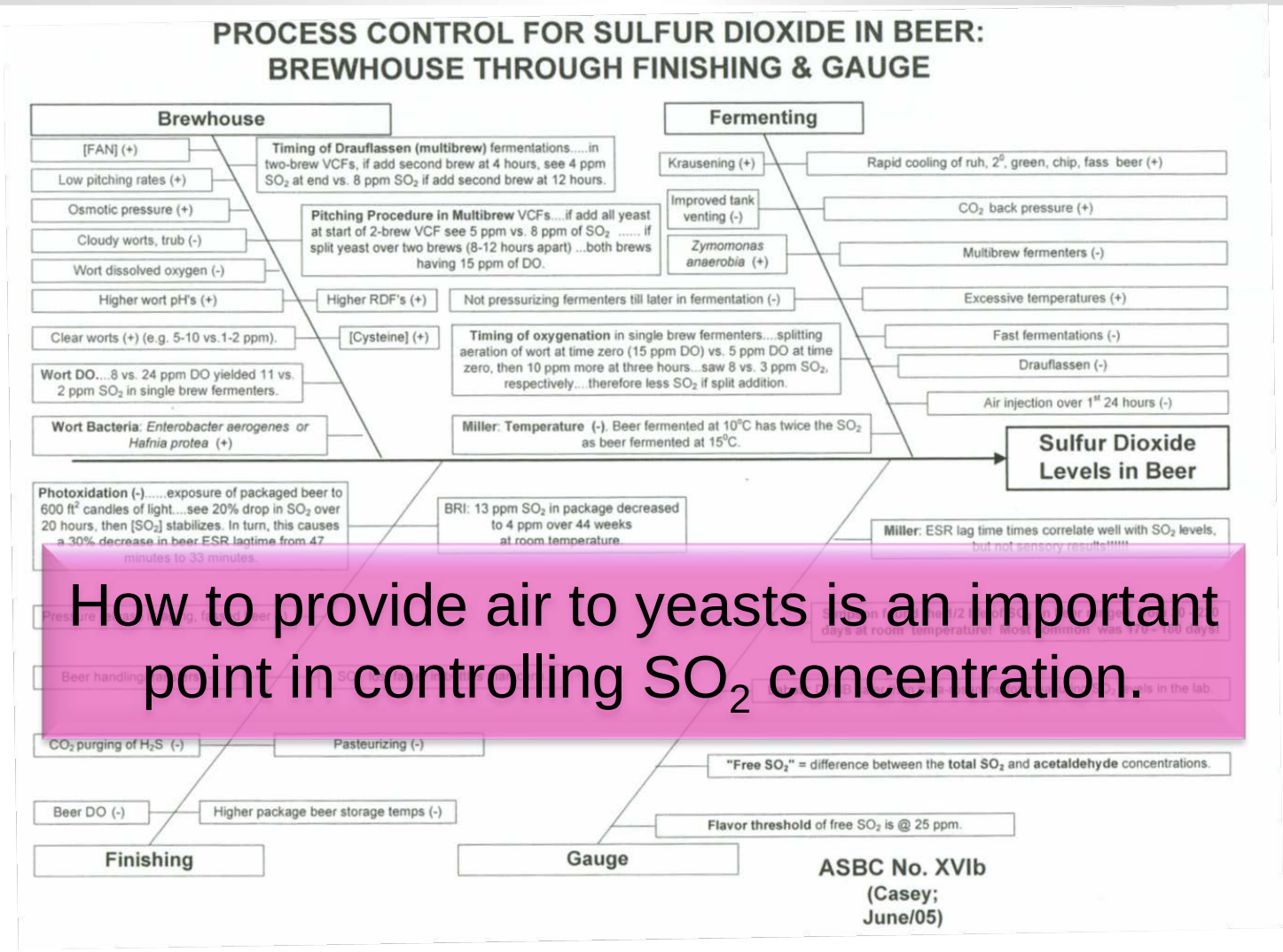
How to control SO_2 concentration



How to provide air to yeasts is an important point in controlling SO_2 concentration.

Gales, W.P (ed.), Brewing chemistry and technology ,178,2007

TDOC (Total Dissolved Oxygen Consumption)

✓ **Dissolved oxygen (DO) intake per unit yeast**

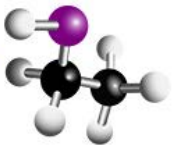
(Mitsui, S., et al., M.B.A.A. Tech.Quart.,28,119, 1991.)

$$TDOC = \frac{\Sigma R_k * a_k}{n}$$

R: Rate of oxygen consumption by the yeast
a: Length of time during which dissolved oxygen is consumed by yeast
n: Number of pitched yeasts

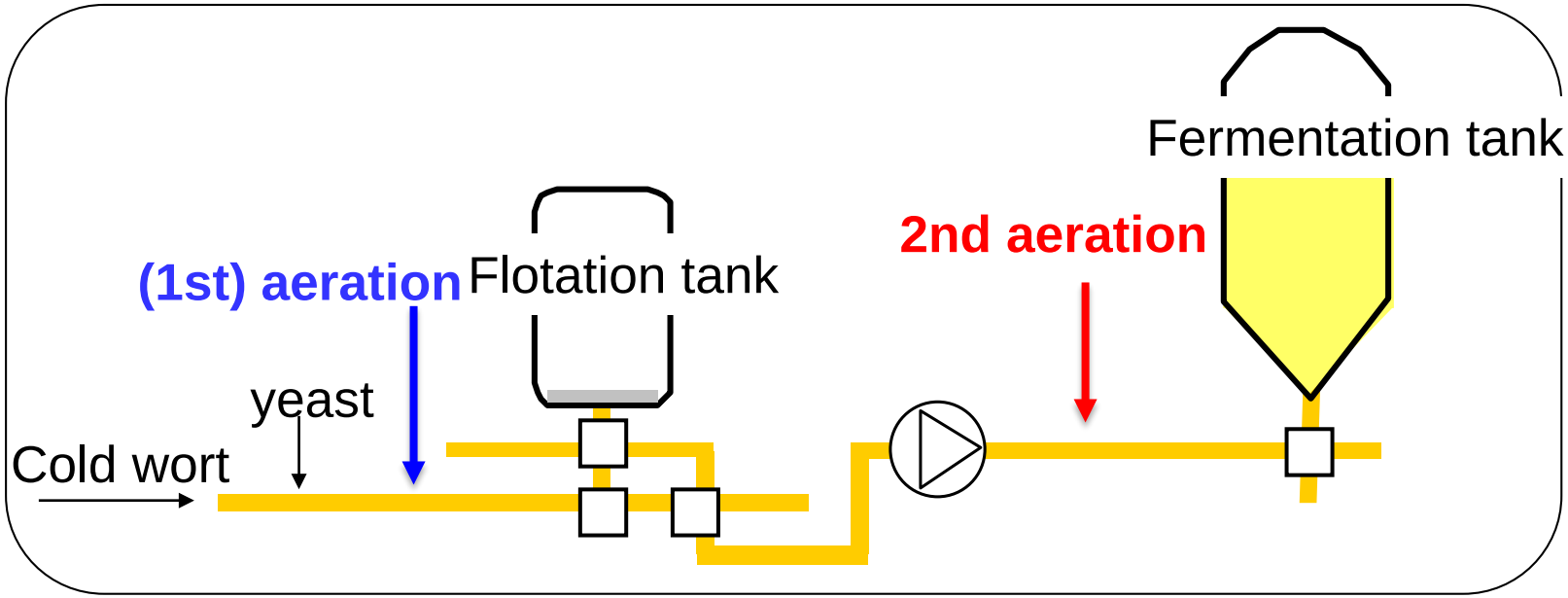
hypothesis

SO_2 ⟷ **Correlation?** ⟷ **TDOC**



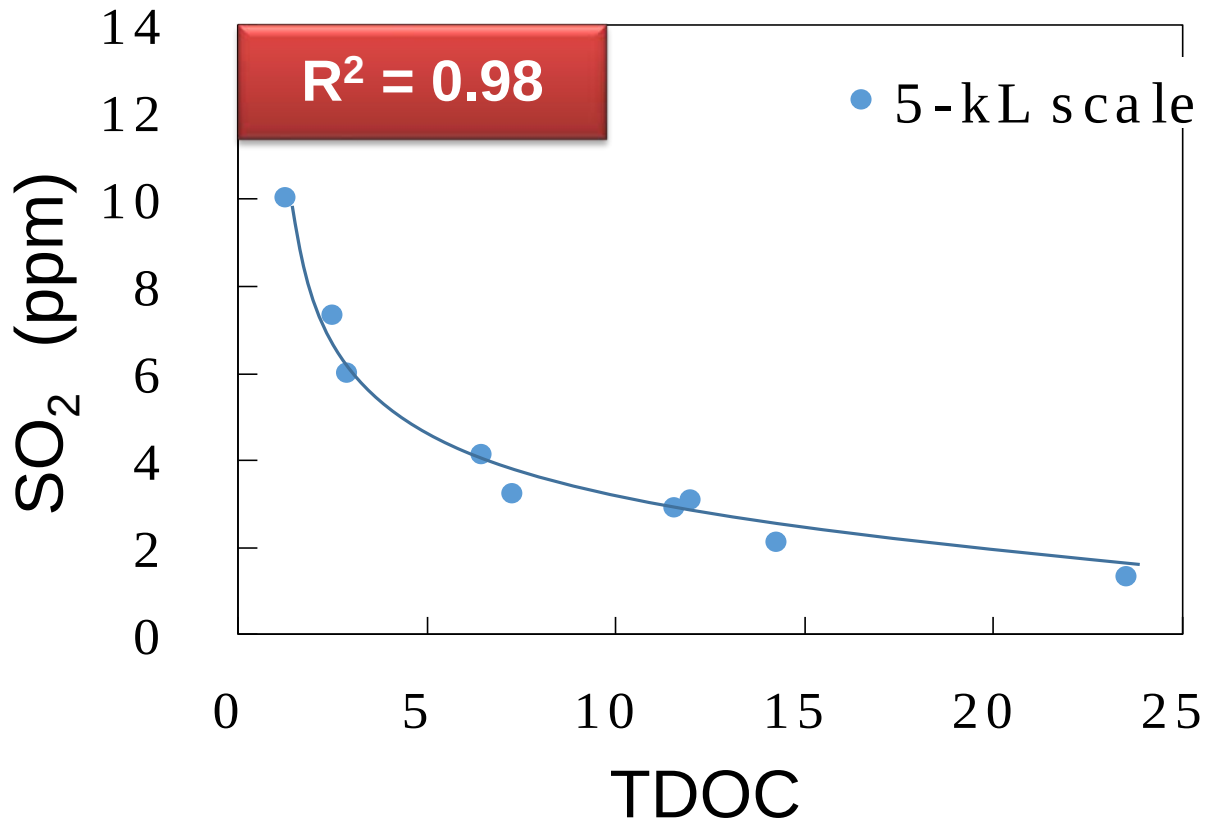
How to control TDOC

We changed the amount of aeration (primary/secondary) and conditions of the flotation process.



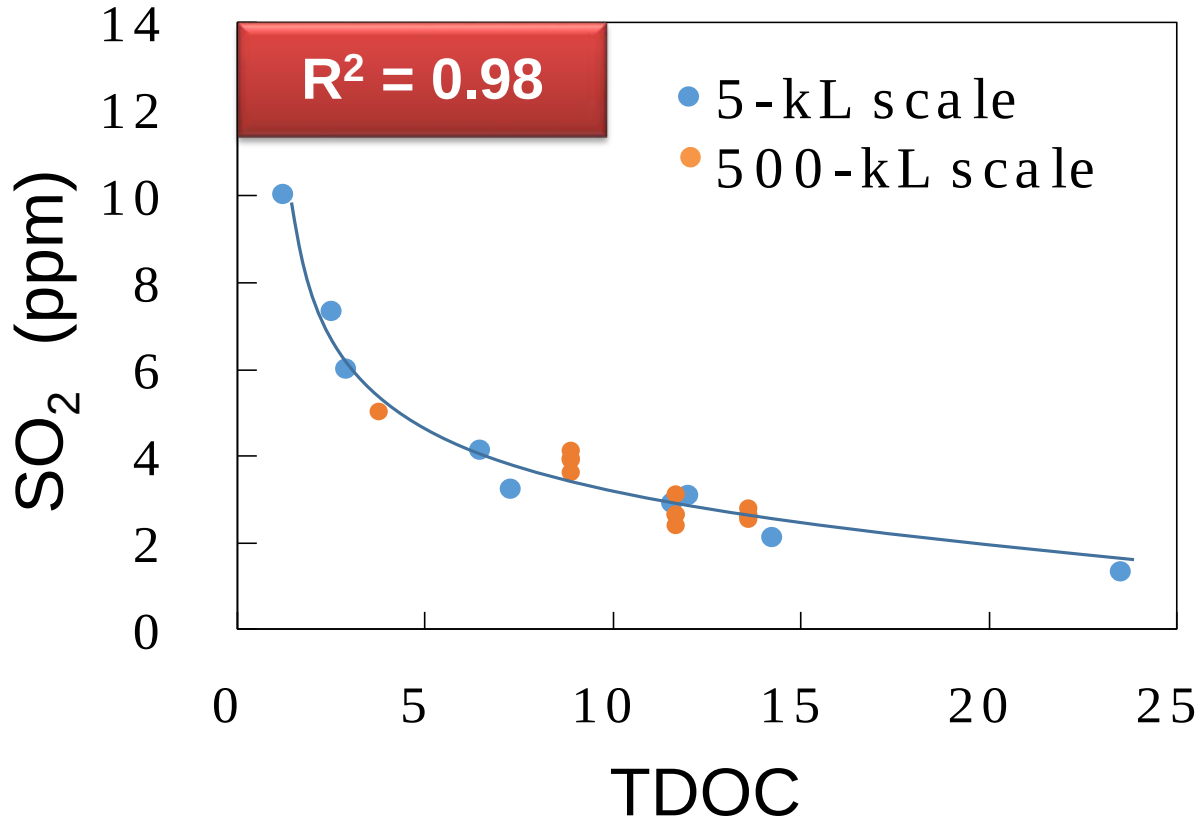
SO_2 control (5-kL scale)

The lower TDOC, the higher SO_2 concentration



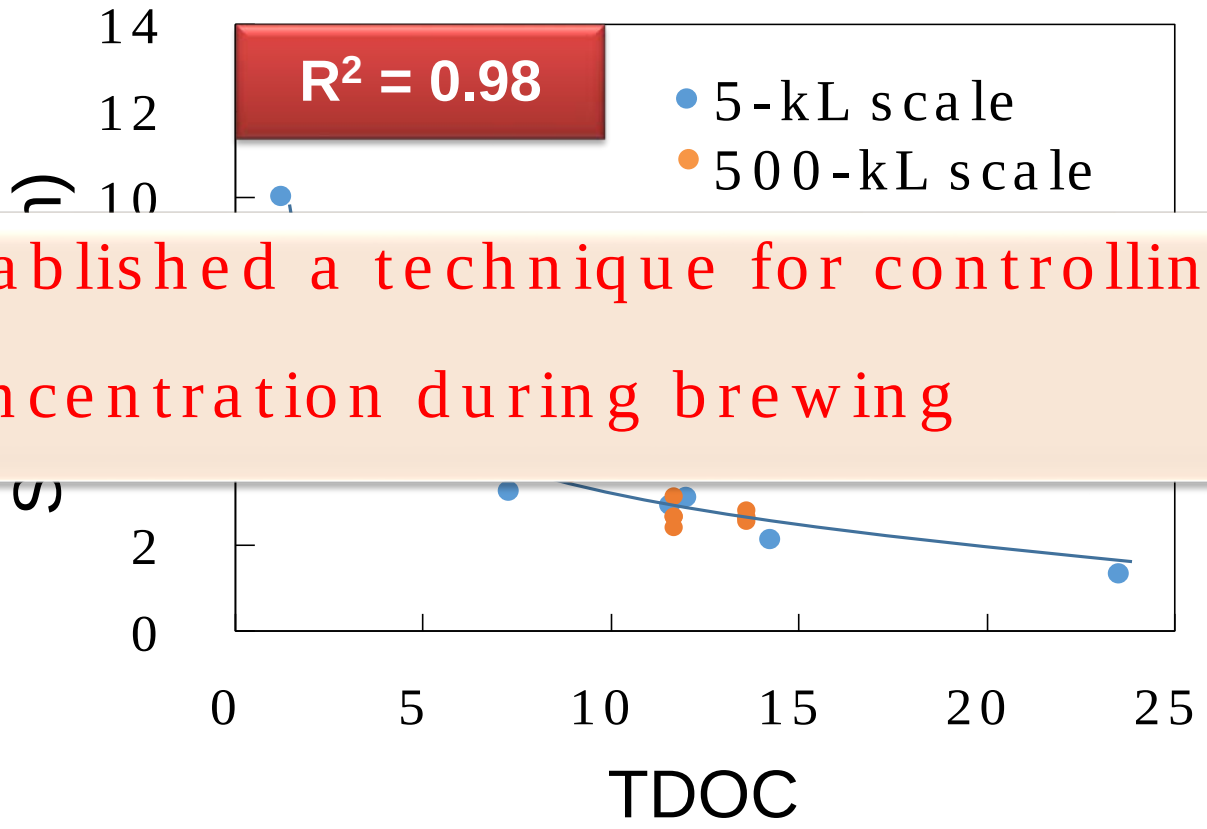
SO_2 control (500-kL scale)

SO_2 concentration can be controlled in manufacturing scale at our brewery.



SO_2 control (500-kL scale)

SO_2 concentration can be controlled in manufacturing scale at our brewery.



We established a technique for controlling SO_2 concentration during brewing

Steps in evaluating SO_2

STEP 3: Evaluation of factory manufactured beer

Transport manufactured beers overseas

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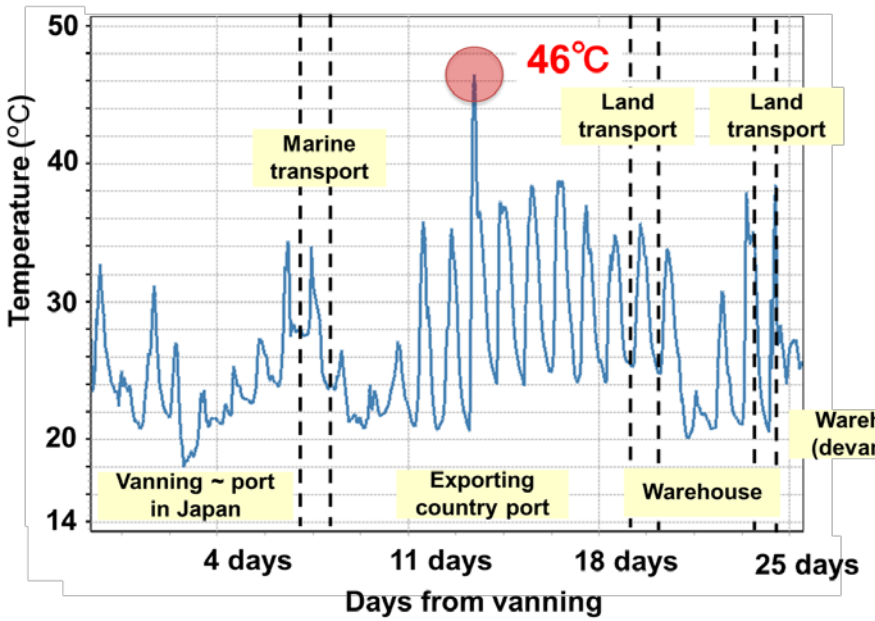
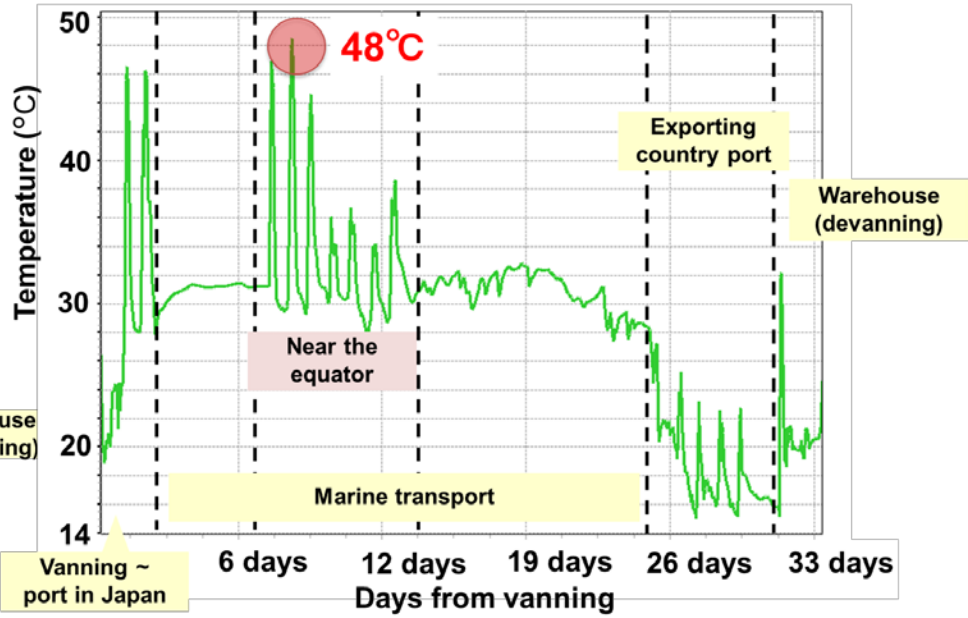
Stored beers at 50 ℃.

STEP 1: Establishment of control technique

At the mini brewery (5-kL) and factory (500-kL) scale.

Confirmation of effects at high temperature





Does SO_2 improve flavor stability even at high temperature?

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Search for new candidate components

Samples

- 3 or 6 ppm SO_2
- Stord
  - -2 or 4 weeks
  - -25,37or 50° C

Sensory evaluation

- **Aging odor**
- **Cardboard odor**
- **Overall oxidation**

Description method

Targeted analysis

GC/MS

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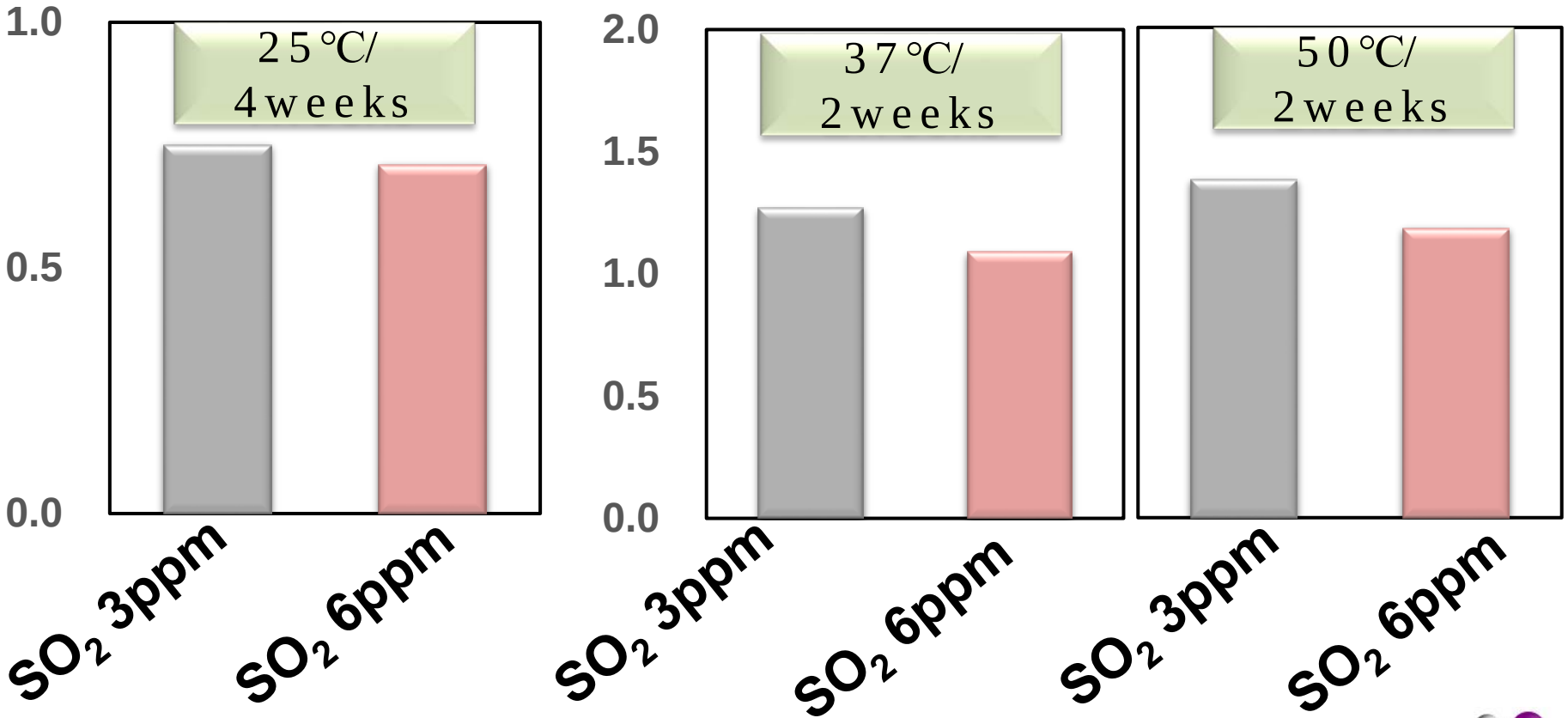
Aging flavor intensity

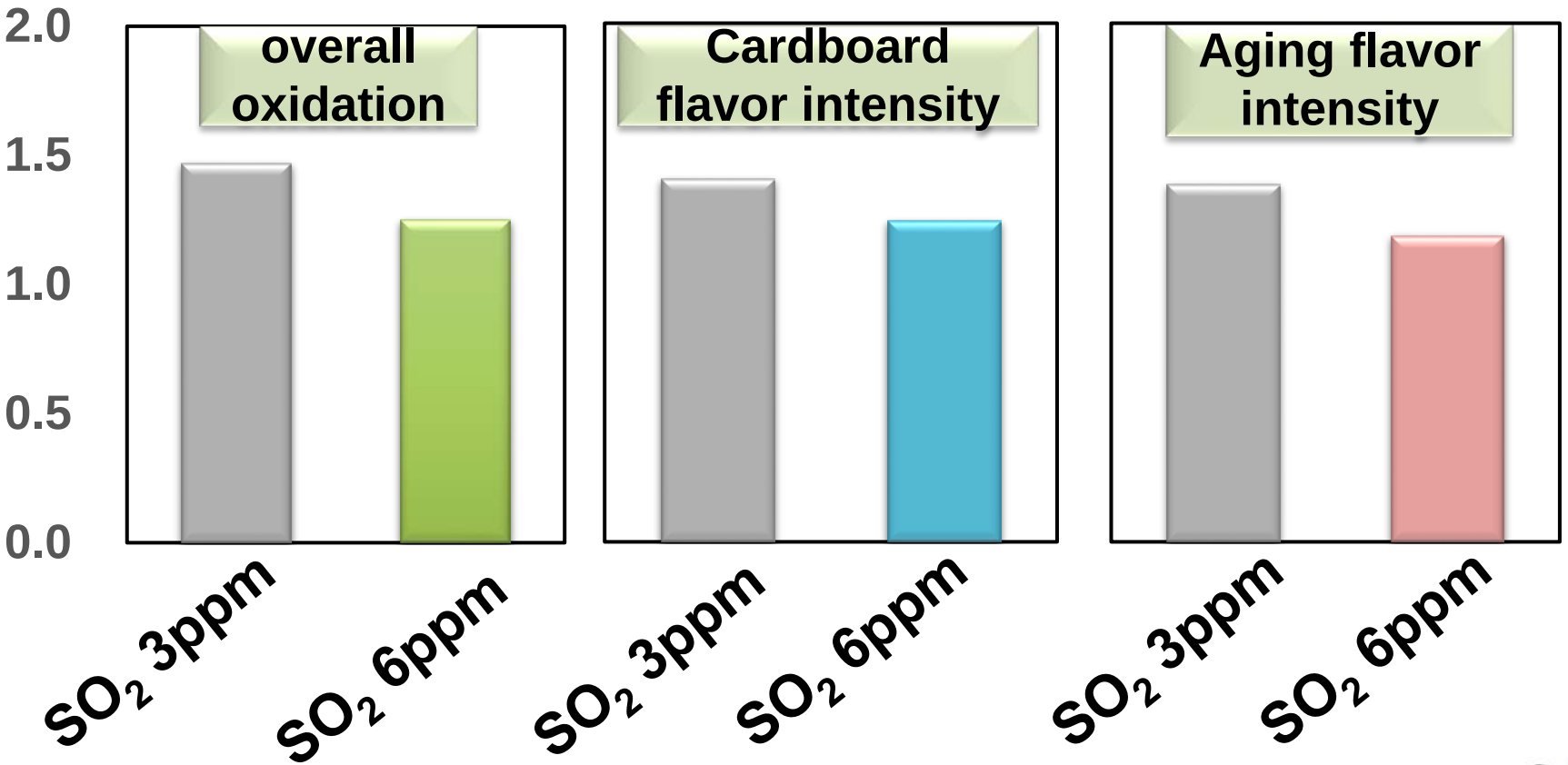
SO_2 prevented the ageing flavor generation under all temperature condition.



Sensory evaluation

50° C for 2 weeks

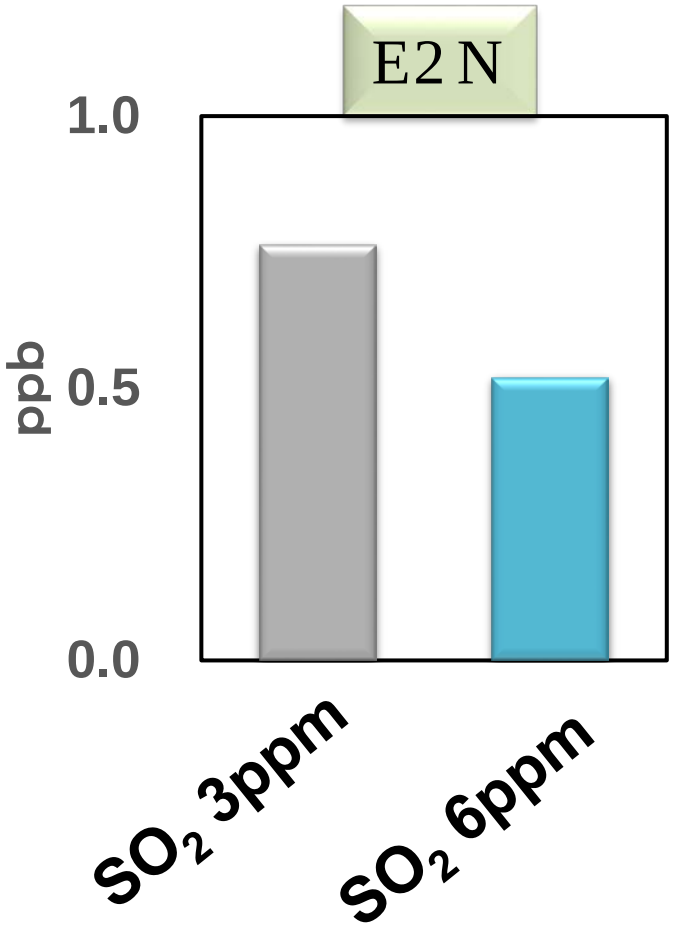
SO_2 improved the flavor stability of products stored even at high temperature.

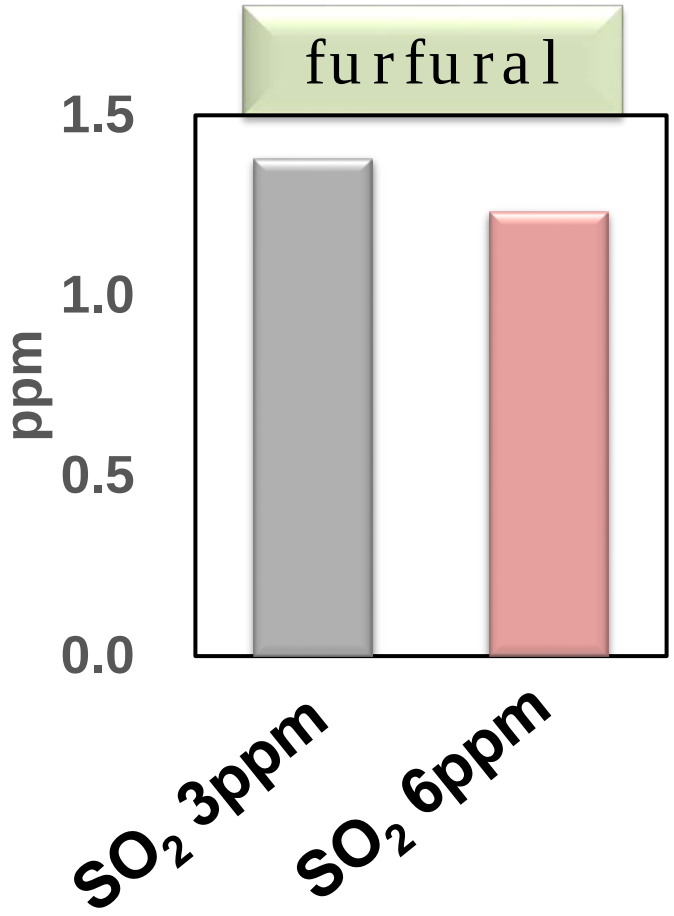


Component analysis

50° C for 2 weeks

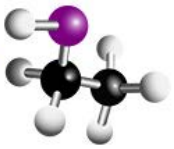
SO_2 prevented E2N and furfural generation.





Short summary 2

- We established a technique that controls SO_2 by TDOC adjustment during brewing.
- SO_2 improved the flavor stability even at high temperatures.



Future plan

STEP 3: Evaluation of factory manufactured beer

Transport manufactured beers overseas

STEP 2: Confirmation of effects at high temperature

Stored beers at 50 ℃.

STEP 1: Establishment of control technique

At the mini brewery (5-kL) and factory (500-kL) scale.

Conclusion

SO_2 level through the brewing process is a predictable and effective method for preventing aging flavor during transportation overseas.