WORLD BREWING CONGRESS
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#ElevateBeer

Sensory and instrumental analyses of compounds affecting the *KIRE* (crispness) of beer

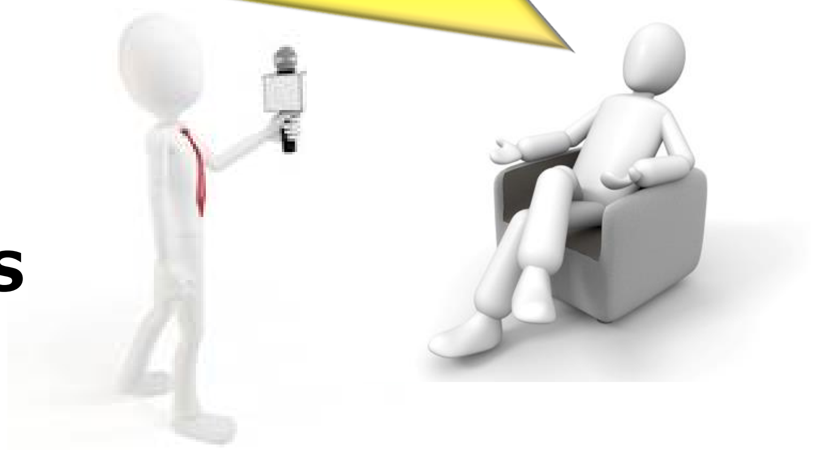
Research Laboratories for Alcohol Beverages
ASAHI BREWERIES, Ltd.

Seiko Miyashita, Minoru Kobayashi, Kaori Kikuchi
Naoki Kato, Susumu Masuda, Masayuki Aizawa

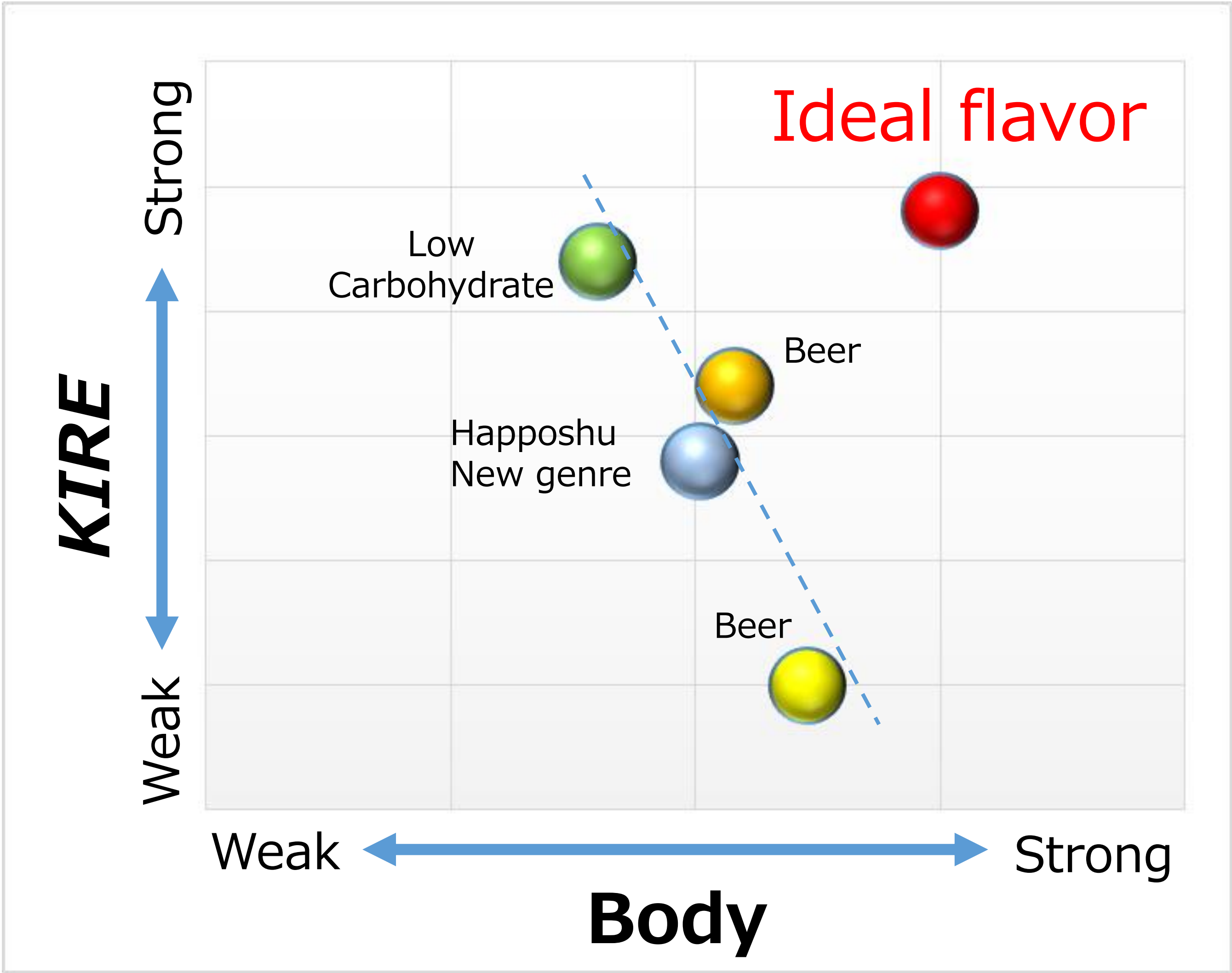
What flavors are desirable in beer?

Full-body, ***KIRE***, pleasant flavor, refreshing, strong bitterness, easy to drink, light taste, clear aftertaste...

"Body" and "*KIRE*" are important characteristics for evaluating beer flavors in the Japanese market



Preference survey by Japanese consumers (2015)



A gap exists between the ideal beer flavor and the body and *KIRE* of commercially available brands

No. 1 beer in the Japanese market

Major characteristic of
"SUPER DRY" is
KIRE

<Objectives>

- ✓ **Examination of the components associated with body and *KIRE* of beer**
- ✓ **Identification of the compounds that contribute to *KIRE***

Aims of this study

To clarify…

① **Whether taste compounds or both taste and aromatic compounds contribute to the body and *KIRE* of beer**

② **The types of compounds that affect *KIRE***

Definitions of body and *KIRE*

Body - Fullness of flavor and mouthfeel

KIRE (Smoothness, Crispness, Cleanness, Refreshing)

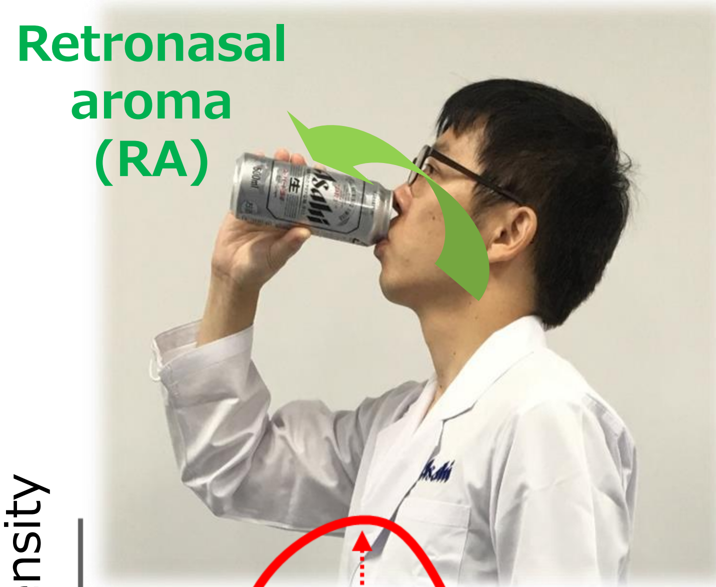
(1) Smooth mouthfeel

(2) Rapid disappearance of flavor and mouthfeel after drinking

(3) No residual flavor or mouthfeel after drinking

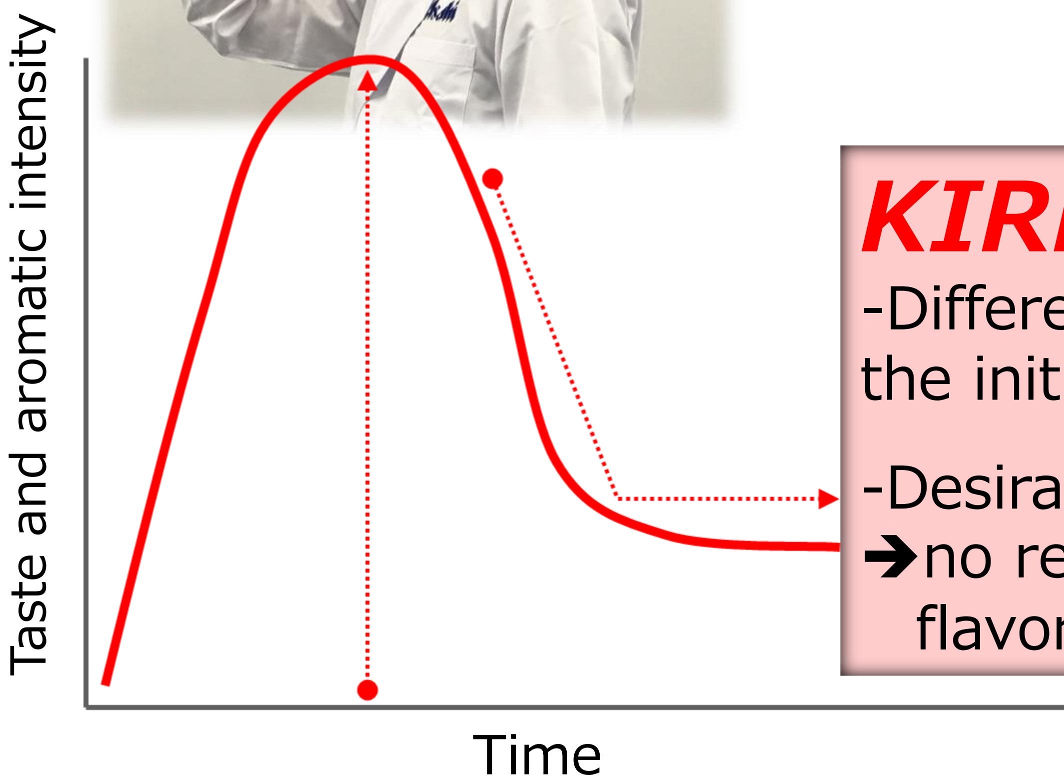
Hirotaka Kaneda, et. al., *J. Am. Soc. Brew. Chem.* 60(2):71-76, 2002

Definitions of body and *KIRE* for this study



Body

-Total volume of taste and aroma



KIRE (Crispness)

-Difference in flavor between the initial and final mouthfeel

-Desirable *KIRE*
➔no residual or unpleasant flavors after drinking

Scheme of this study

Comprehensive data acquisition

Sensory and instrumental analyses of commercially available Japanese beer brands

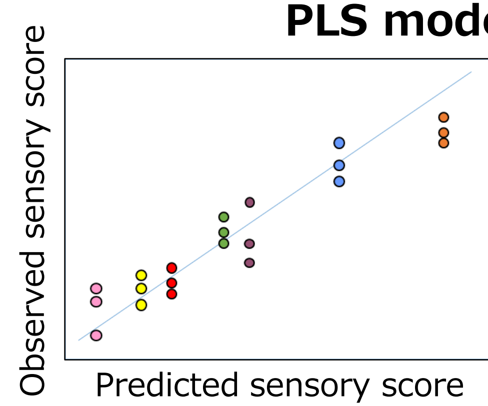
GC
Volatile analysis

HPLC
Nonvolatile analysis

Multivariate analysis

Selection and identification of compounds highly correlated with body and *KIRE* by partial least squares (PLS) regression analysis

PLS model



Sensory evaluation

Confirmation that the candidate compounds affect the *KIRE* of beer

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Analysis of 14 brands produced by major breweries in Japan

Beer

Happoshu ／New genre (Regular)

Happoshu ／New genre (Low Carbohydrate)

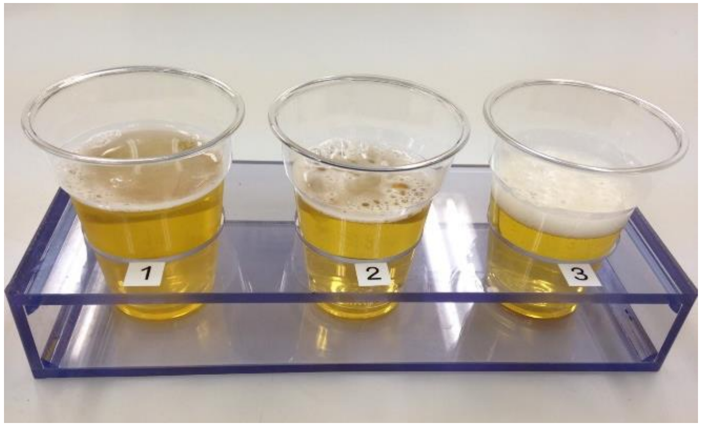
Sensory analysis

Quantitative descriptive analysis (QDA)

Attributes: Body (1: weak ↔ 9: strong)

KIRE (1: weak ↔ 9: strong)

Method: Blind tasting- no information about samples



Comprehensive component analyses

Analysis of compounds relating to taste

Amino acids, Sugars, Free amino nitrogen, Total nitrogen,
Bitterness unit (B.U.), pH,
Original gravity (P), Alcohol (v/v),
Real extract (%), Real degree of fermentation (%),
Apparent extract (%),
Apparent degree of fermentation (%),
Apparent final extract (%),
Apparent attenuation limit (%),
Color (°EBC), and CO_2 pressure (MPa)

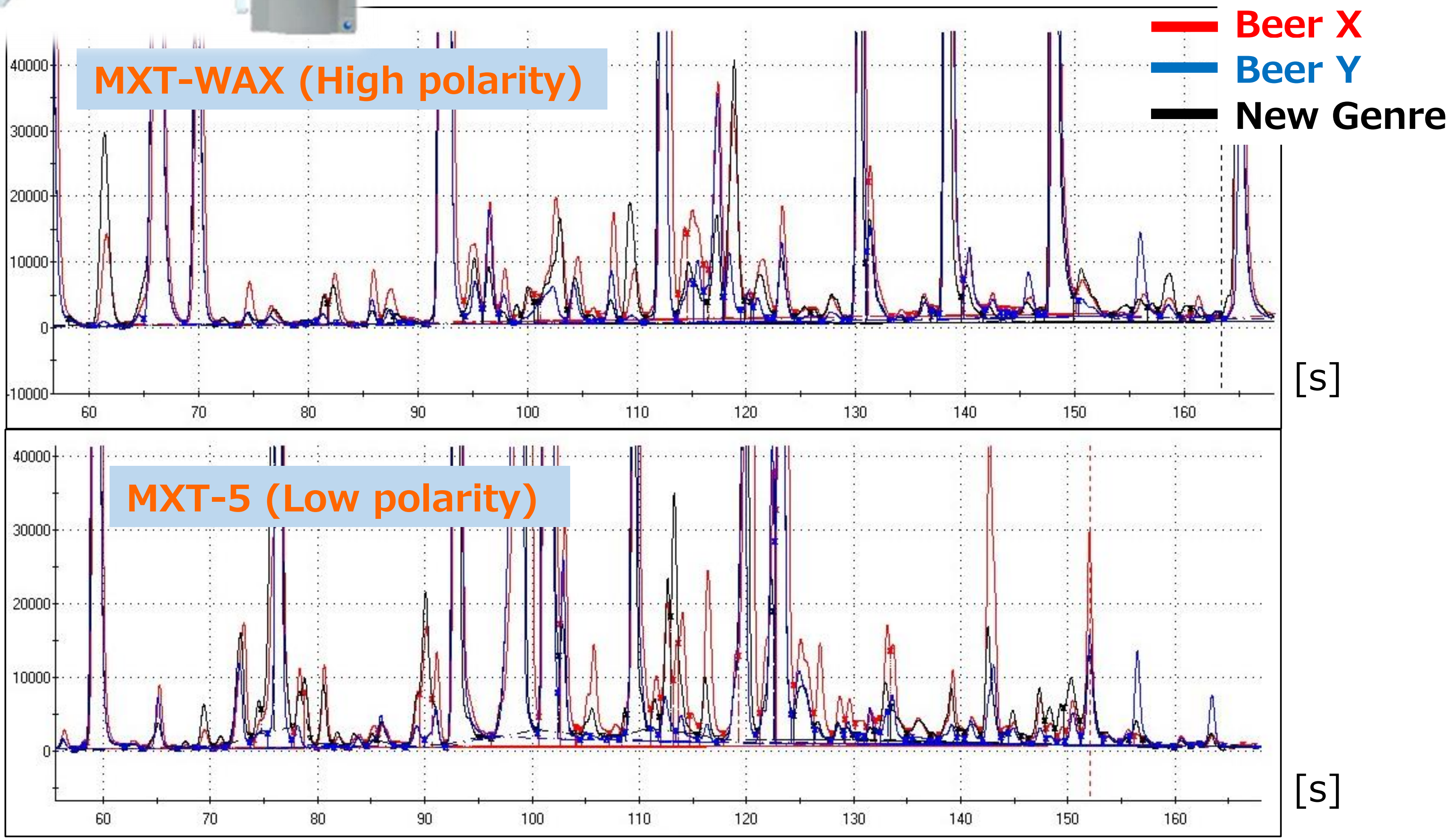
HPLC

Aromatic compound analysis

GC
(Flash GC Nose by Alpha MOS Co.)

Flash GC Nose System by Alpha MOS Co.

The Flash GC Nose system can analyze about two hundred aromatic compounds using two columns of different polarities in parallel



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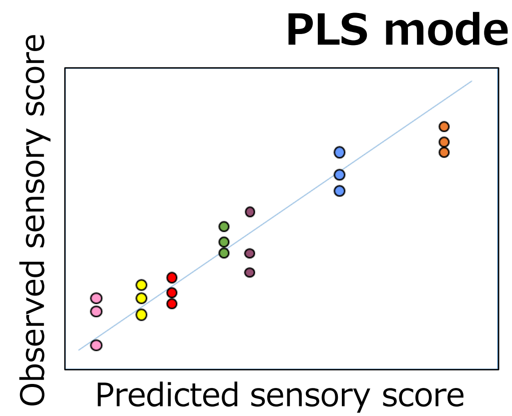


Sensory evaluation

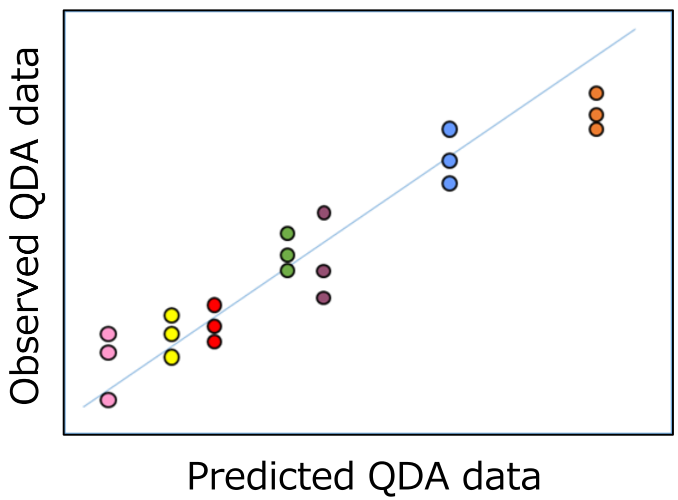
Confirmation that the candidate compounds affect the *KIRE* of beer

Multivariate analysis

PLS regression analysis

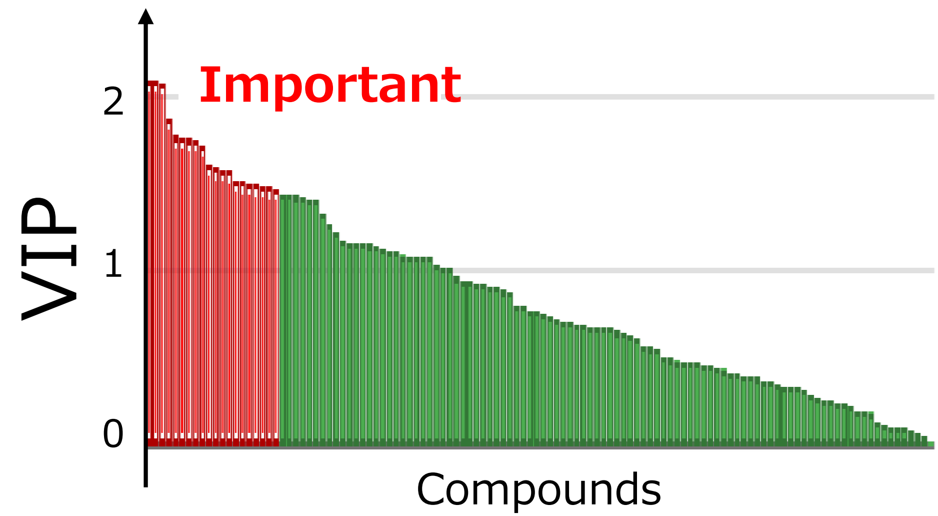
- A regression method commonly used to examine the relationship between X and Y variables in multivariate data

Quality-Predictive Model



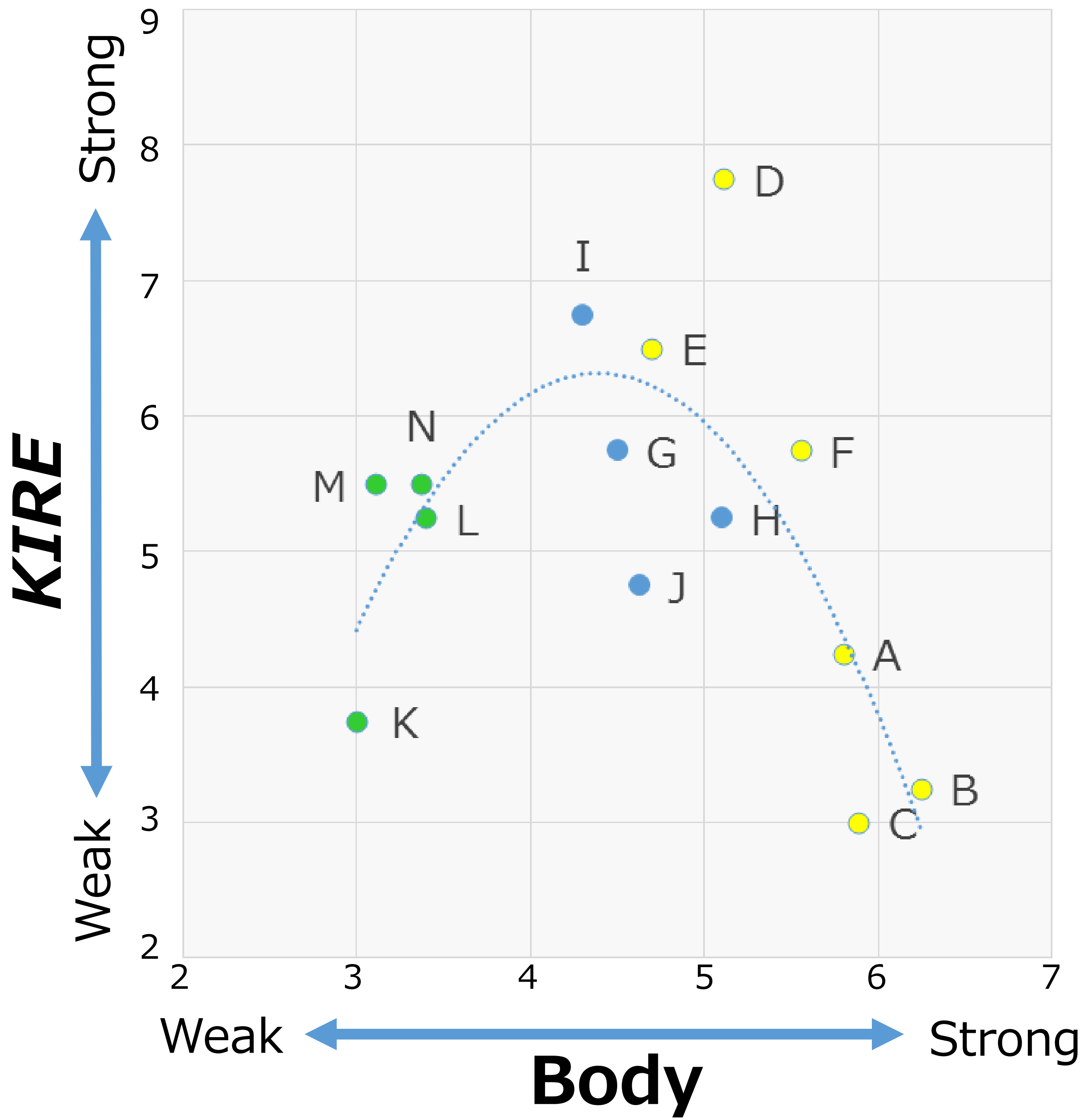
Construction of predictive model for QDA data using PLS

Selection of important compounds



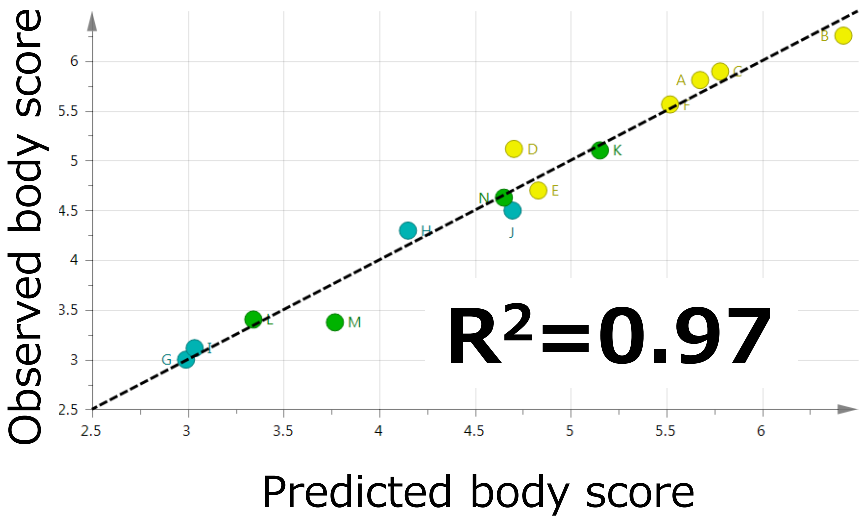
Selection of candidate compounds affecting body and *KIRE* based on variable importance in the projection (VIP) values

QDA data of the 14 beer samples

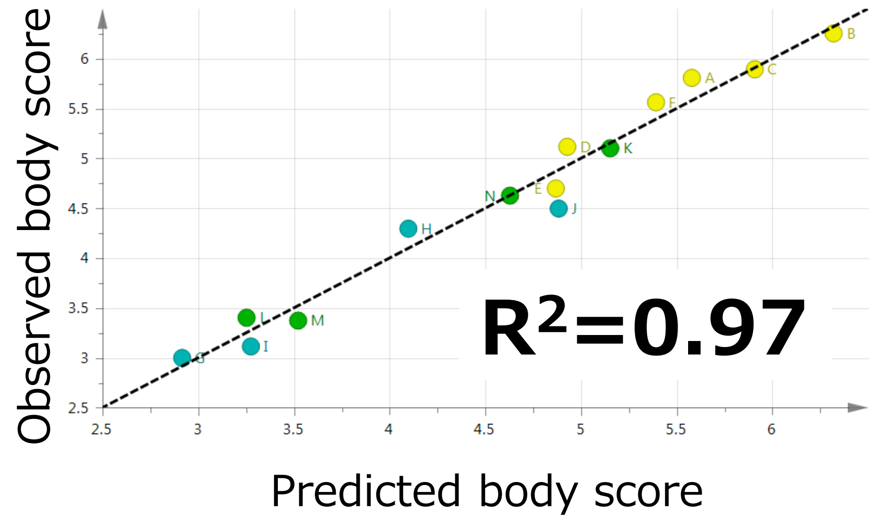


PLS models to predict QDA data for body

X=Taste compound data



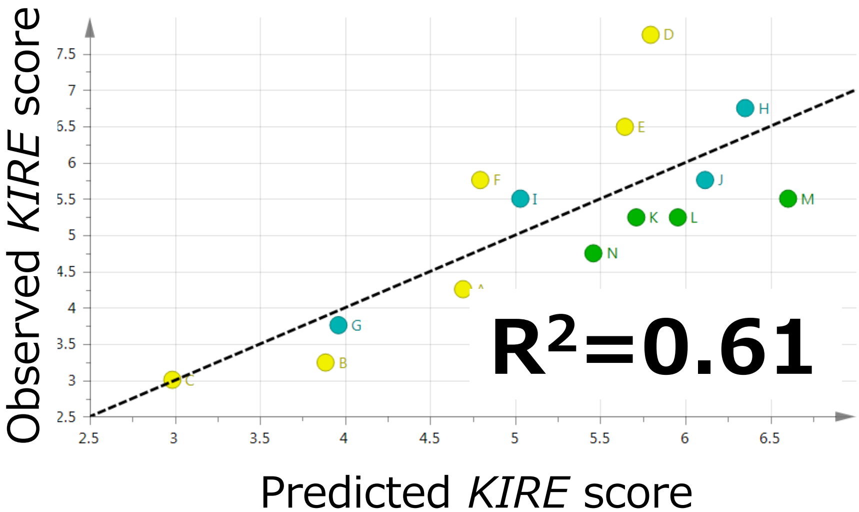
X=Taste and aromatic compound data



Taste compounds appear to have a strong effect on the body of beer and play an important role in the determination of body

PLS models to predict QDA data for *KIRE*

X=Taste compound data



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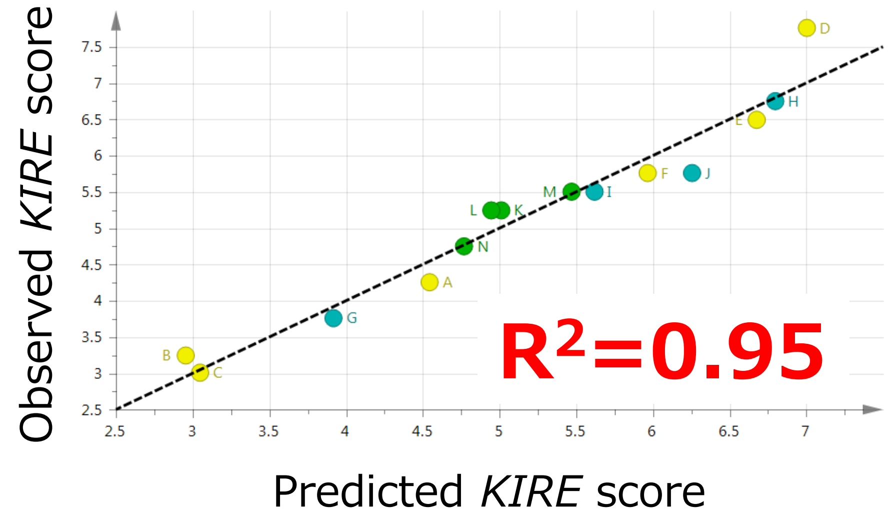
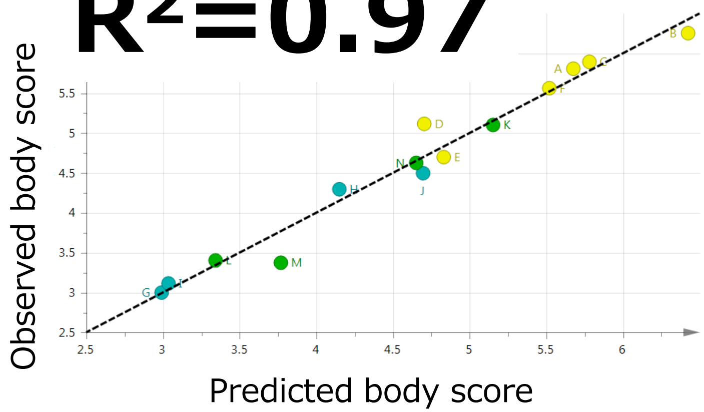
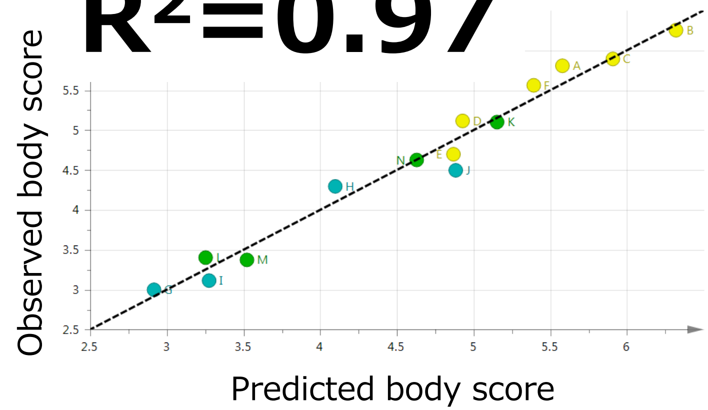
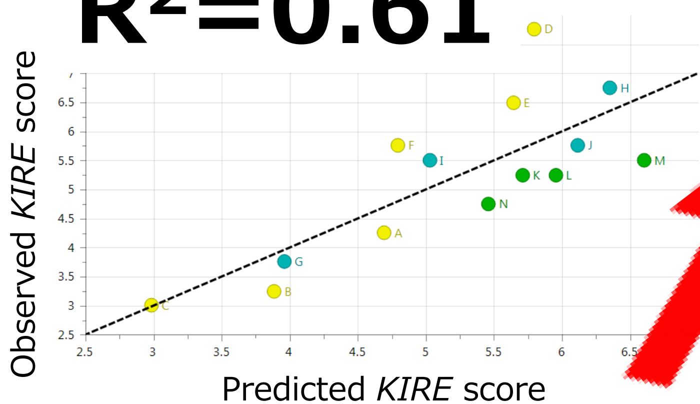
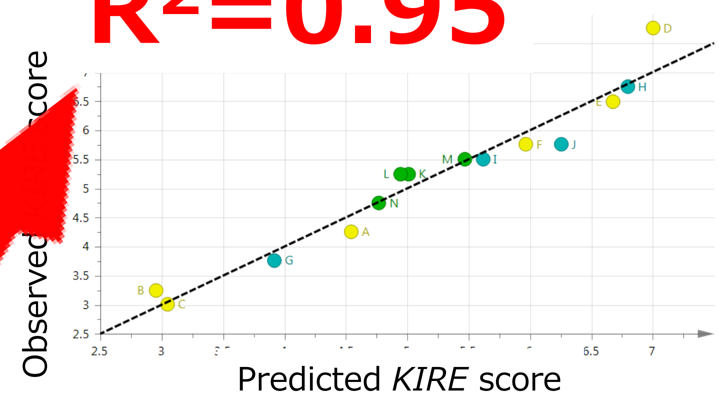


Both taste and aromatic compounds appear to affect *KIRE*

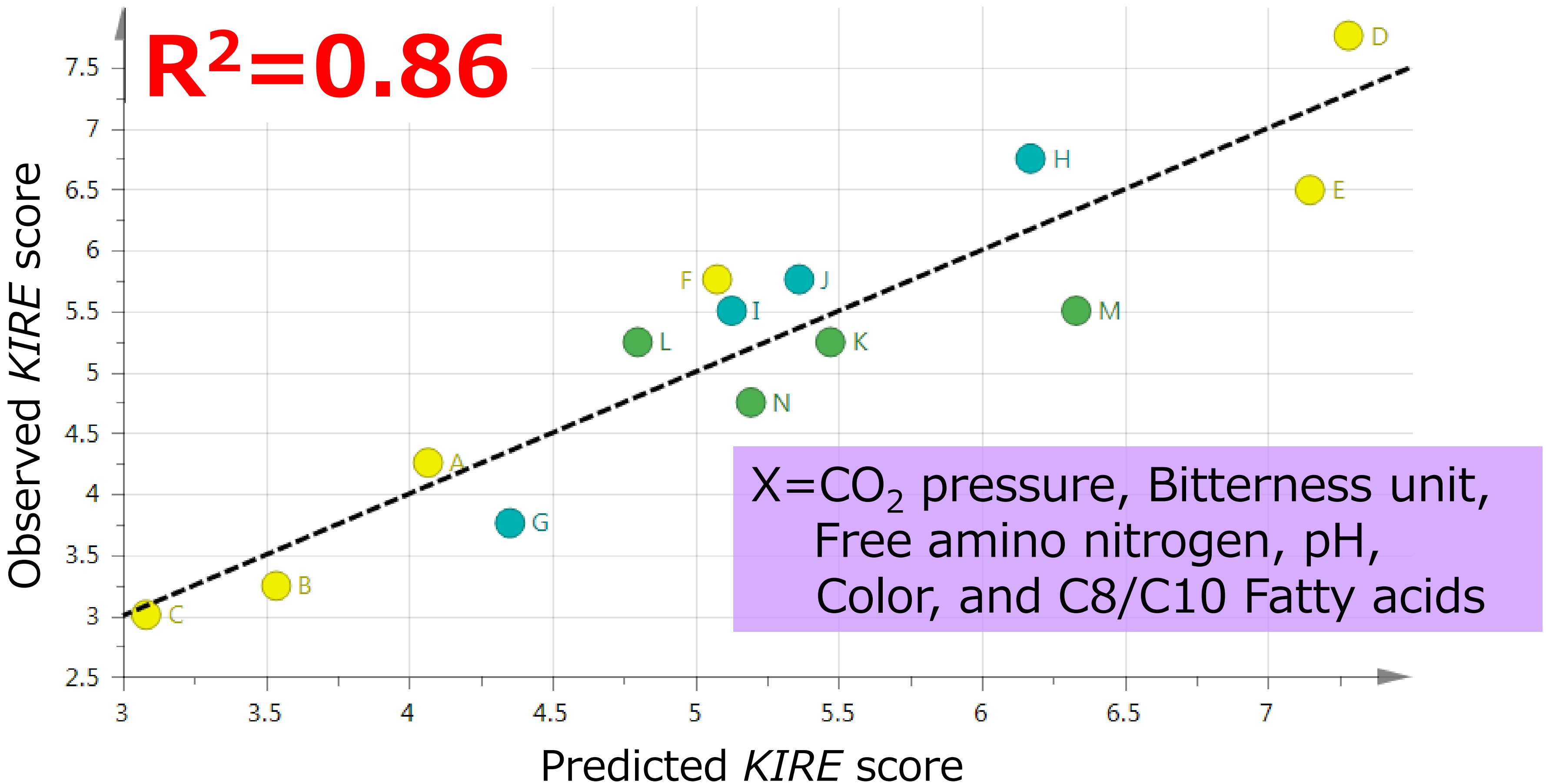
Comparison of R^2 values of the PLS models

	Explanatory variables	
	Data set for taste compounds	**Data sets for taste and aromatic compounds**
Body	R^2=0.97 	R^2=0.97 
KIRE	R^2=0.61 	R^2=0.95 

Aromatic compounds highly correlated with *KIRE*

Compound	VIP	Relation to "*KIRE*"
C8 Fatty acid	2.44	Negative
C10 Fatty acid	1.53	Negative
C8 Fatty acid ethyl ester	4.59	Negative
C10 Fatty acid ethyl ester	3.54	Negative
β-Myrcene	2.70	Negative
Phenylethyl acetate	1.84	Negative
Isoamyl alcohol	1.23	Positive

Validation of the *KIRE* prediction model



A high-quality *KIRE* prediction model was constructed using 7 analysis items that were selected and identified in the PLS models

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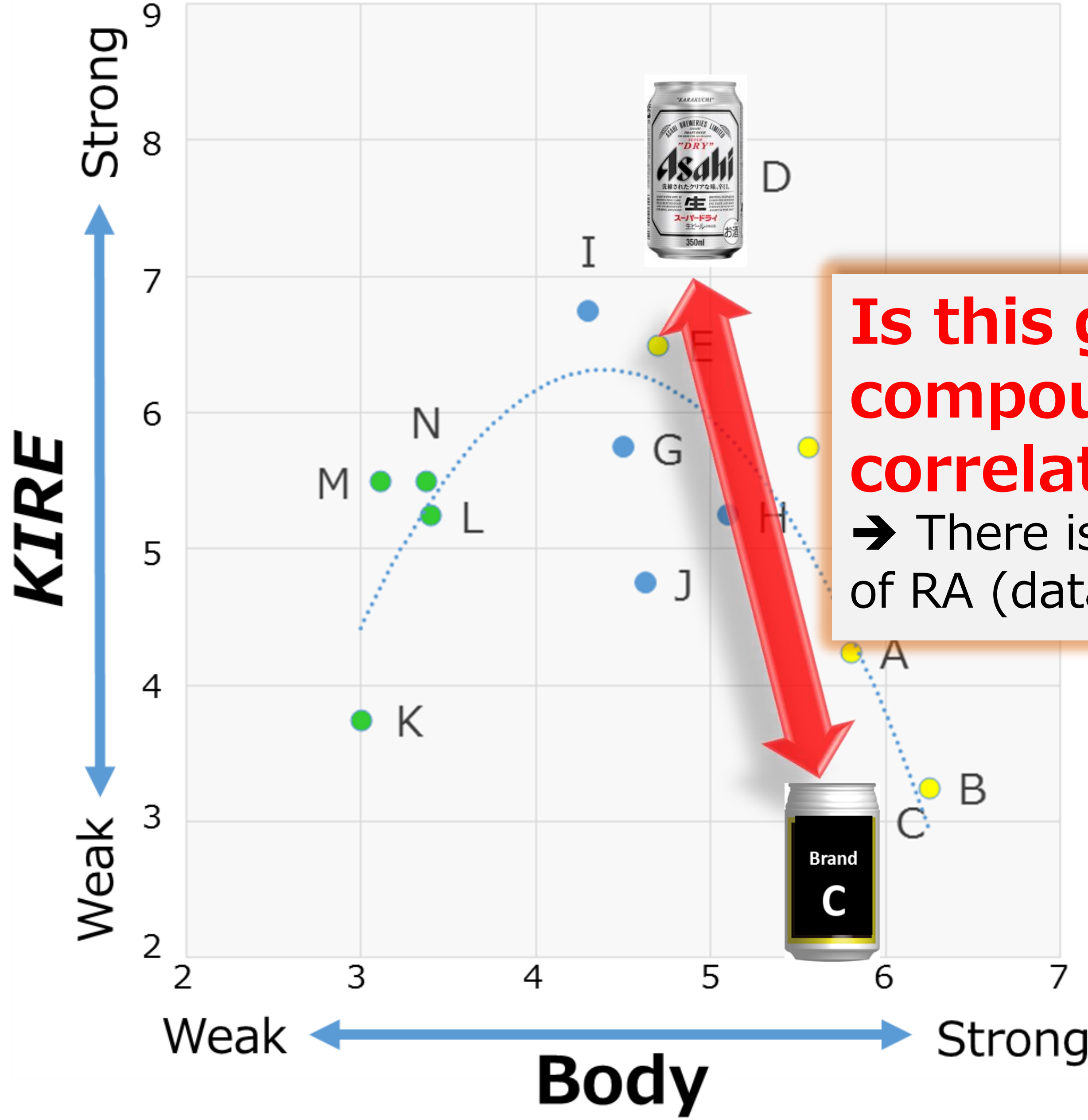
PLS model

Sensory evaluation

Confirmation that the candidate compounds affect the *KIRE* of beer

QDA of the 14 beer samples



Is this gap due to the compounds highly correlated with *KIRE*?

➔ There is a difference in terms of RA (data not shown)

Sensory evaluation

Sample		Added compound(s)	Amount added ※Relative to the difference between the control and Brand C	
Control (SUPER DRY) 		–	–	–
Test sample	A	All candidate compounds affecting *KIRE*	×1	×2
	B	C8/C10 Fatty acids	×1	×2
	C	C8/C10 Fatty acid ethyl esters	×1	×2

Attribute: *KIRE* (1: weak ↔ 7: strong)

Method: Each sample was presented in a cup covered with a plastic lid to eliminate orthonasal aroma

A) Effect of all candidate compounds in combination on *KIRE*

Compound	VIP	Relation to "*KIRE*"
C8 Fatty acid	2.44	Negative
C10 Fatty acid	1.53	Negative
C8 Fatty acid ethyl ester	4.59	Negative
C10 Fatty acid ethyl ester	3.54	Negative
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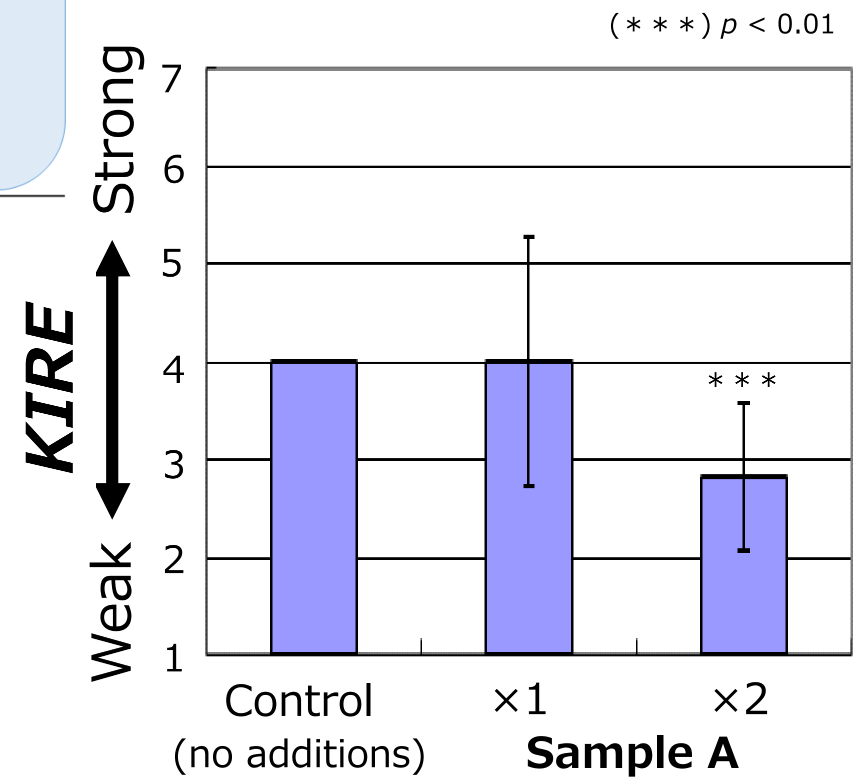

B) Effect of C8/C10 fatty acids on *KIRE*

Compound	VIP	Relation to "*KIRE*"
C8 Fatty acid	2.44	Negative
C10 Fatty acid	1.53	Negative
C8 Fatty acid ethyl ester	4.59	Negative
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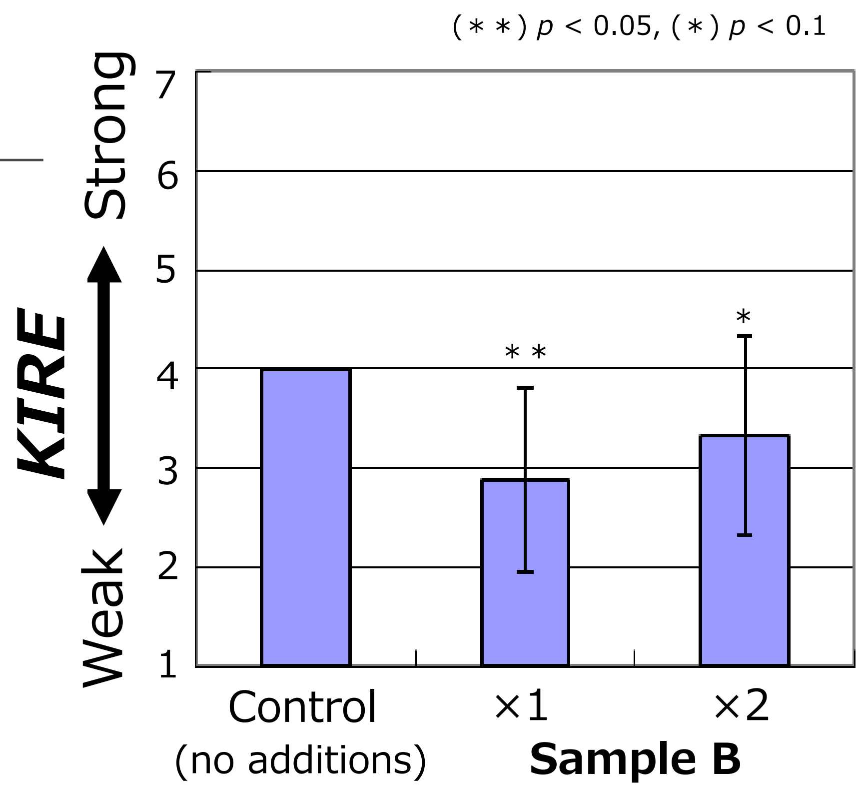
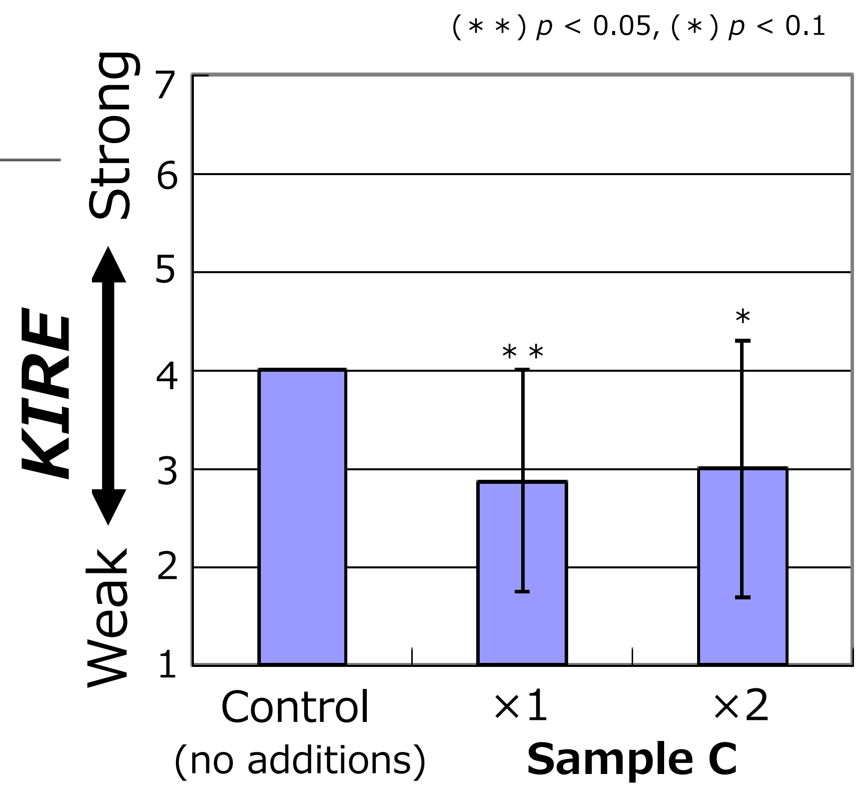


C) Effect of C8/C10 fatty acid ethyl esters on *KIRE*

Compound	VIP	Relation to "*KIRE*"
C8 Fatty acid	2.44	Negative
C10 Fatty acid	1.53	Negative
C8 Fatty acid ethyl ester	4.59	Negative
C10 Fatty acid ethyl ester	3.54	Negative
β-Myrcene	2.70	Negative
Phenylethyl acetate	1.84	Negative
Isoamyl alcohol	1.23	Positive



Conclusions

- ✓ **Taste compounds appear to have a strong effect on the body of beer and play an important role in the determination of body**
- ✓ **C8/C10 fatty acids, C8/C10 fatty acid ethyl esters, β-myrcene, and phenylethyl acetate were negatively correlated with *KIRE***
- ✓ **Sensory evaluations suggested that all of the candidate compounds suppress *KIRE* when added in combination**
- ✓ **C8/C10 fatty acids and their ethyl esters were also confirmed to significantly suppress *KIRE***

Future work

Next step is to find ways to control and improve *KIRE*