Development of Technique for Estimation of Geographical Origin of Food Using Stable Isotope and Trace Element Analyses

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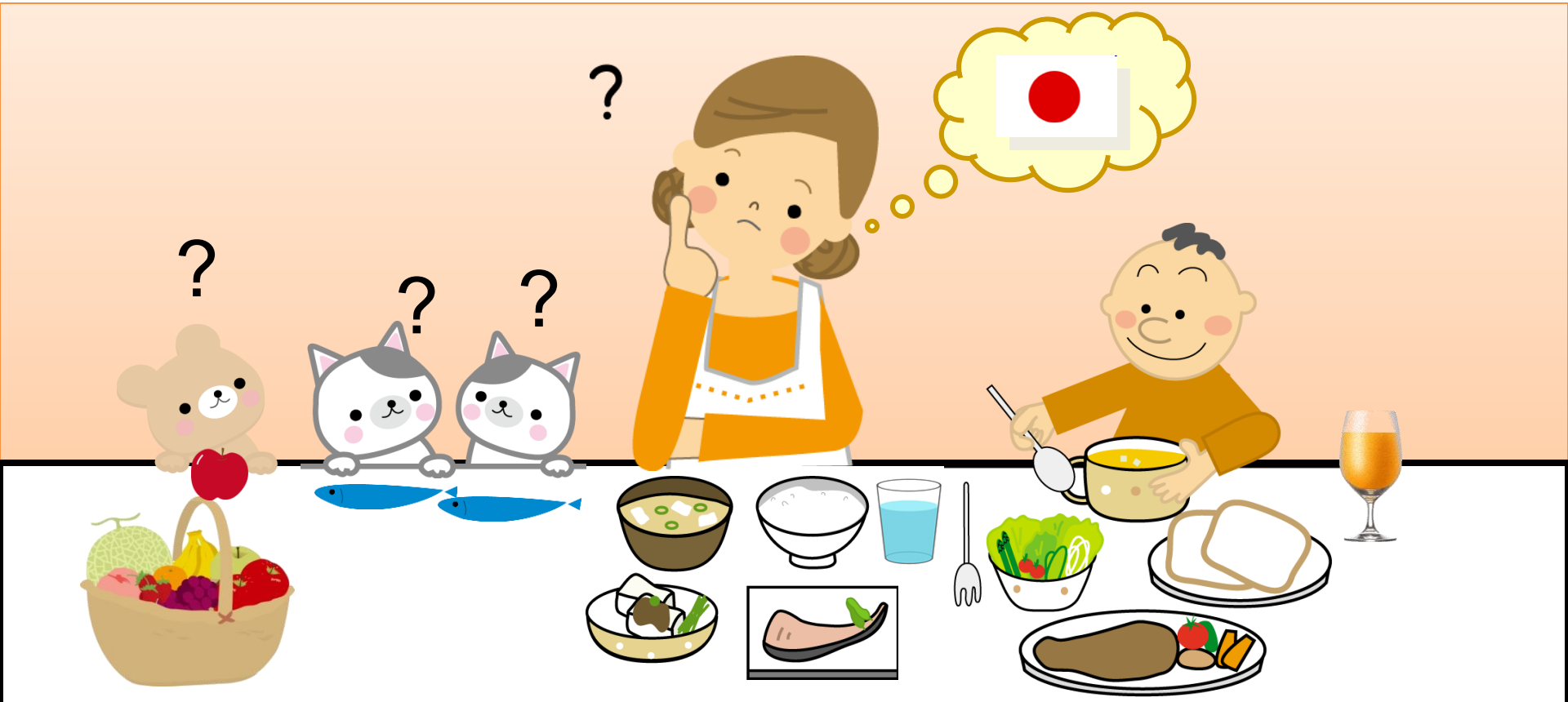
Outline

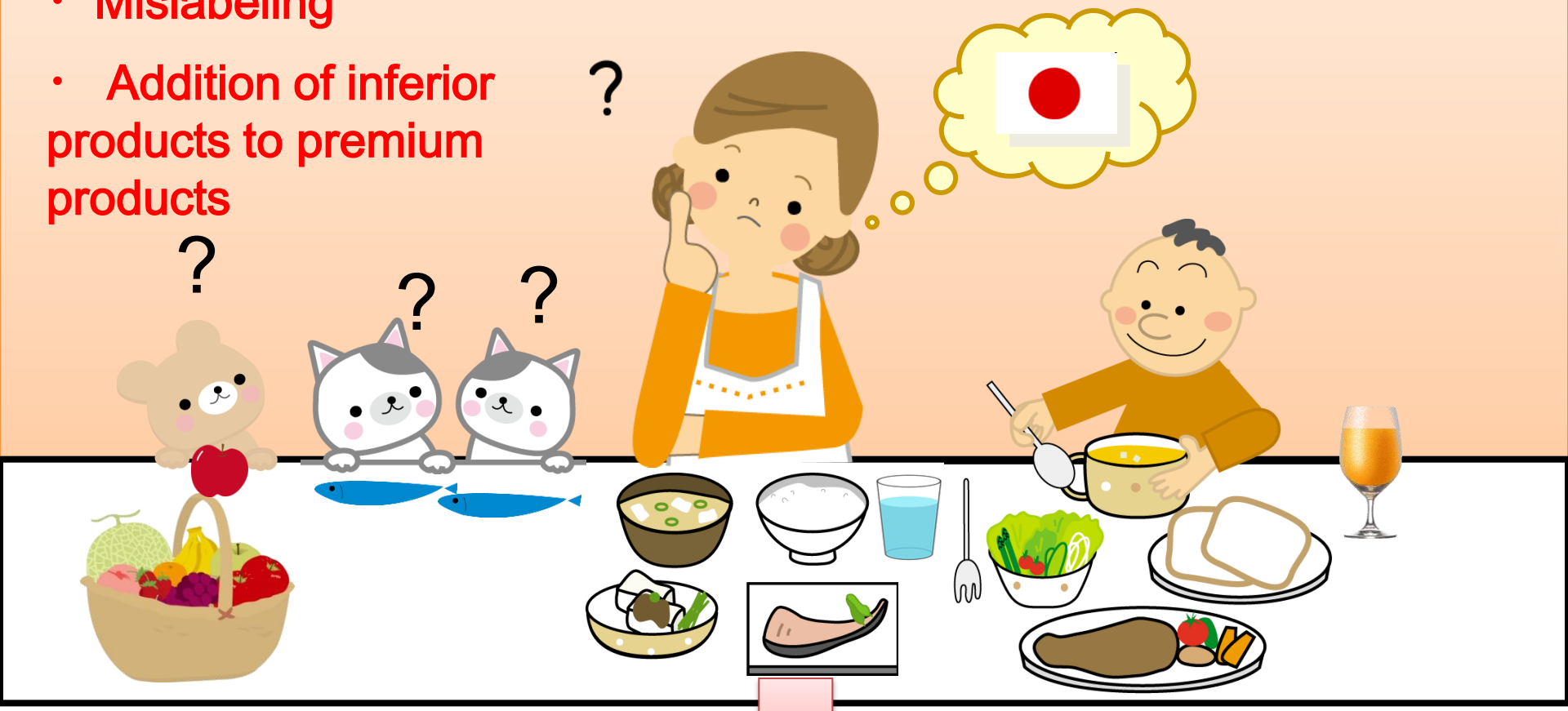
1. Brief Introduction of Food Authenticity
2. Explain Some of Results (Beef and Whisky)
3. The combined use of multiple analytical method to improve the accuracy



Food fraud is a big problem in Japan

Food Authenticity Problems

- Mislabeling
- Addition of inferior products to premium products



There is a need for analytical method to check where our food come from!

Analytical Approach to Food Authenticity

Identification of Cultivar

DNA Analysis

Discrimination of Cultivation Area

Stable Isotope Analysis

$\delta^{13}C$ ・ $\delta^{15}N$ ・ $\delta^{18}O$ ・ δD etc

- $^{15}N/^{14}N$ → Soil nutrition
- $^{13}C/^{12}C$ → Carbon fixation process
- $^{18}O/^{16}O$ → Local groundwater

Trace Element Analysis

Li・Mg・Al・K・Ca・Mn etc

- Soil: the geological profile is unique
- Plant: reflecting the soil composition in which plant is grown

Stable Isotope

Light-element(Hydrogen・ Carbon・ Nitrogen・ Oxygen) stable isotope

Relative abundance data for the isotopes of elements commonly analysed by IRMS [3]

Element	Isotope	Relative abundance (%)
Hydrogen (H)	^{1}H	99.984
	^{2}H	0.0156
Carbon (C)	^{12}C	98.892
	^{13}C	1.108
Nitrogen (N)	^{14}N	99.635
	^{15}N	0.365
Oxygen (O)	^{16}O	99.759
	^{17}O	0.037
	^{18}O	0.204
Sulphur (S)	^{32}S	95.02
	^{33}S	0.76
	^{34}S	4.22
	^{36}S	0.014

Isotopes are defined as atoms of the one element that differ in the number of neutrons percent in their Nuclei.

NARO

Stable Isotope Ratio

$^{13}C/^{12}C$, D/H, $^{15}N/^{14}N$, $^{18}O/^{17}O/^{16}O$

Difference in Mass between isotopes of same element

The lighter isotope is more reactive, hence is concentrated in reaction products and substrate are enriched with the heavier isotope.

substrate product

(Fry, Stable Isotope Ecology, 2006)

Isotope Analysis for Food Fraud
(Carbon・ Nitrogen・ Oxygen・ Hydrogen)

Light element isotope ratios in organism are reflected to their growth environments (e.g. diet, fertilizer, geographical origin).

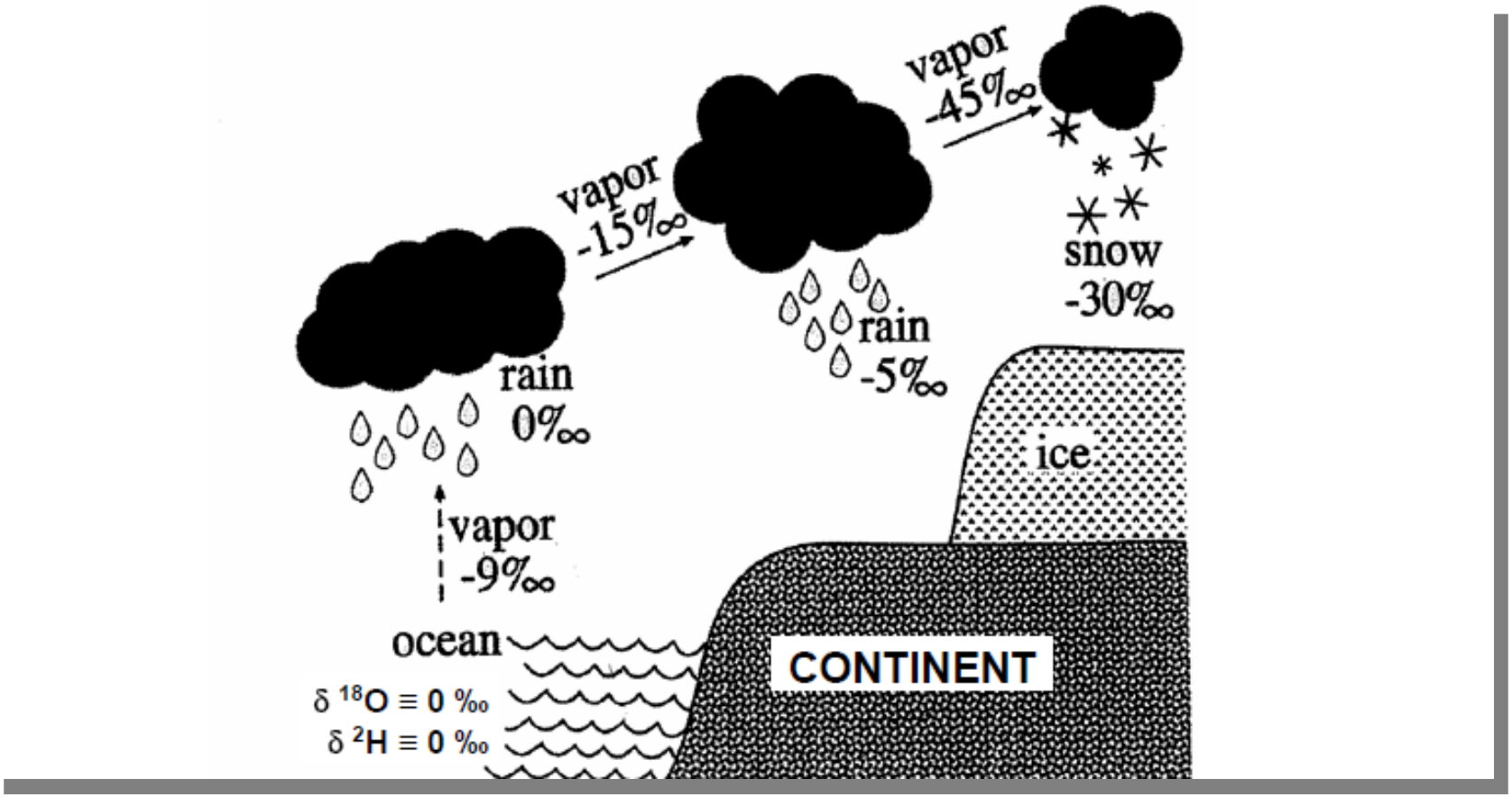
Each element will provide different information.

Isotope Ratio	Main Factor	Information
$^{13}C/^{12}C$	C3 and C4 plan	Addition of Sugar, Diet
$^{15}N/^{14}N$	Trophic Level, Feltilizer	Diet, Organic
$^{18}O/^{16}O$ D/H	Evaporation, condensation, precipitation	Geographical Origin

Multi-Element Stable Isotope Ratios
= “Fingureprint”

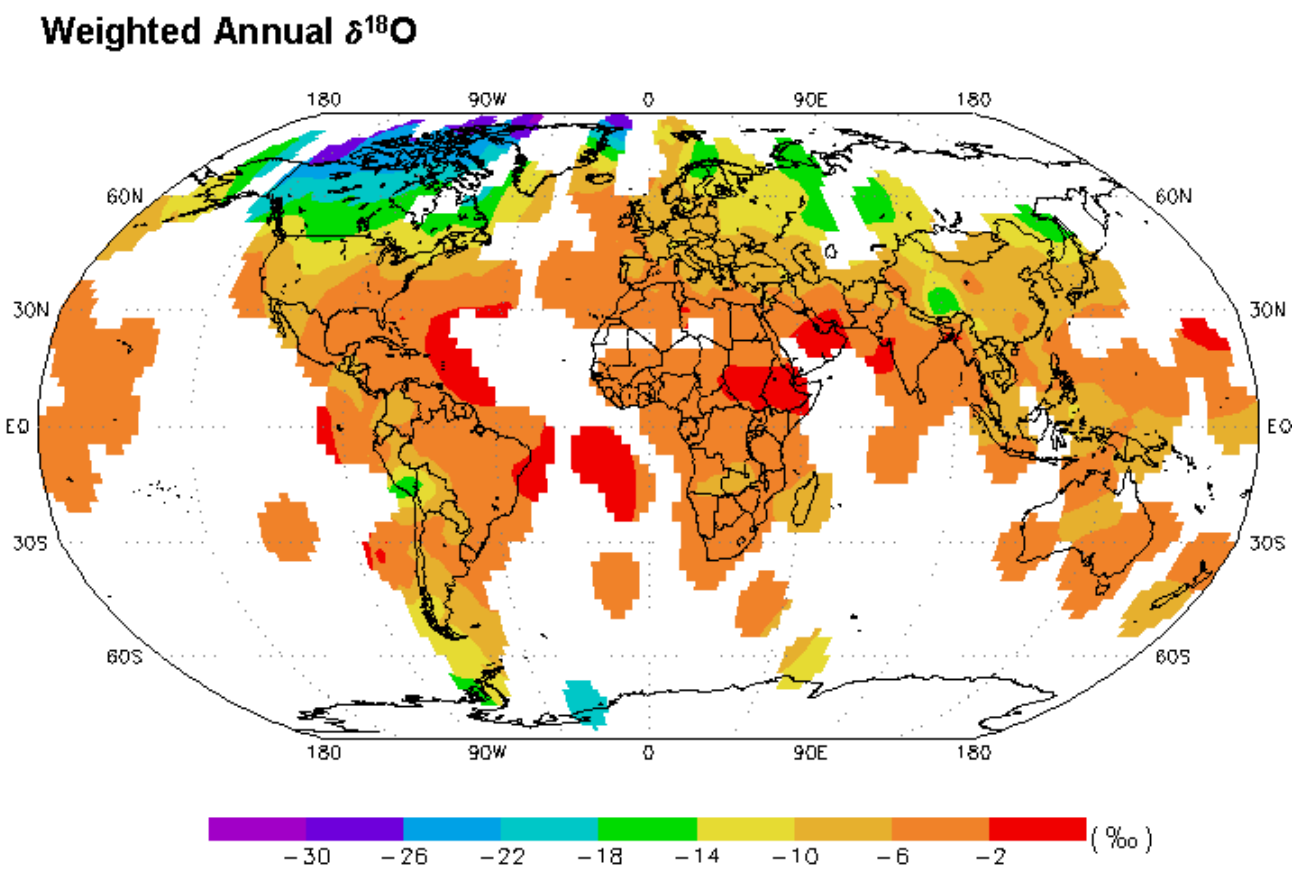
Oxygen and Hydrogen Isotope Ratios of Precipitation

Heavier isotopes (D and ^{18}O) preferentially fall out of precipitation first, leaving a residual cloud mass that is isotopically depleted.



- Oxygen and hydrogen isotope ratios in organism is mainly reflected to those of drinking water.

Global Map of Oxygen Isotope Ratios of Preticipation



Variation
-30 ~ -2‰

IAEA Data base (2002)

Oxygen and hydrogen isotope ratios in Organism

Geographical Data

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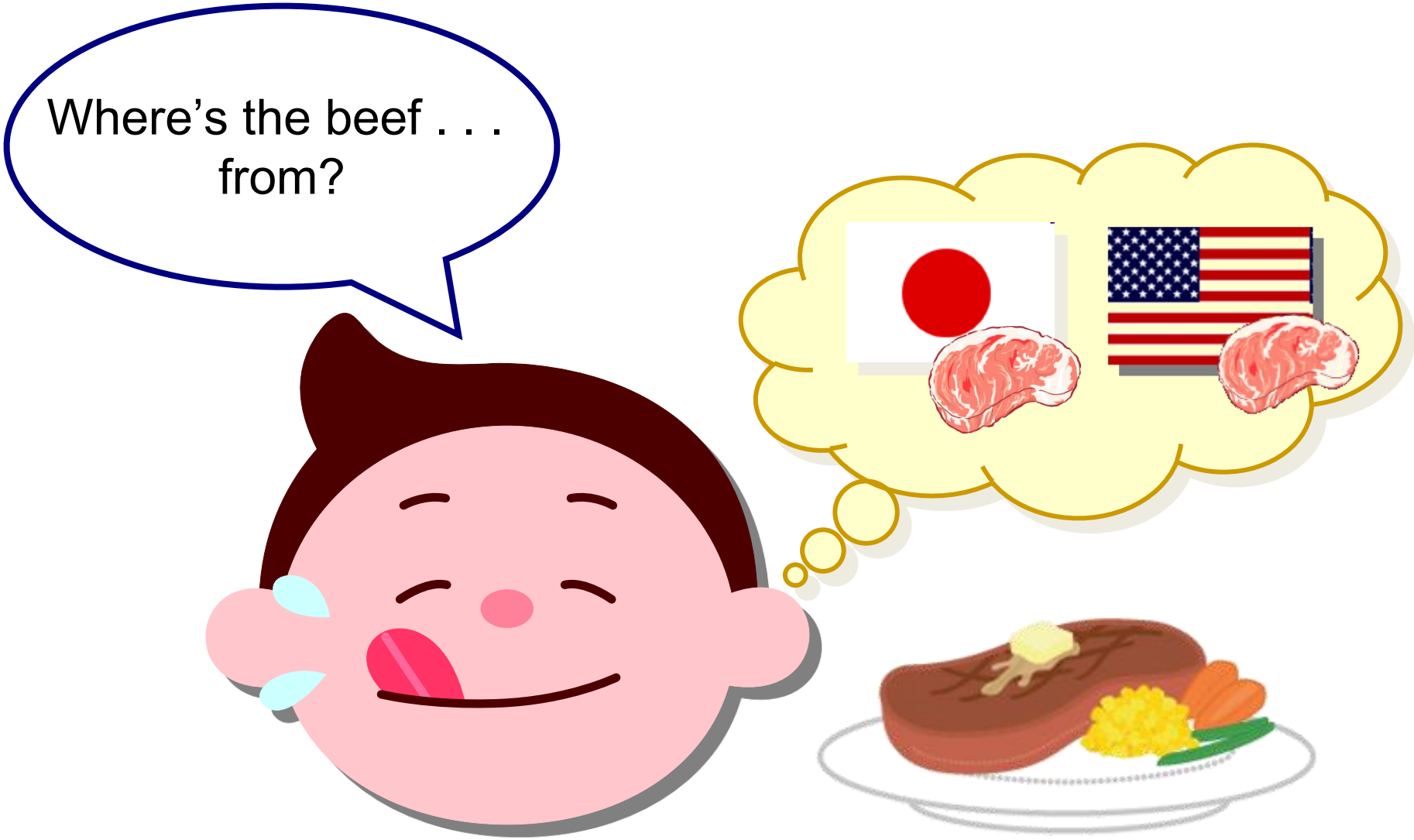
Where are your food products from?



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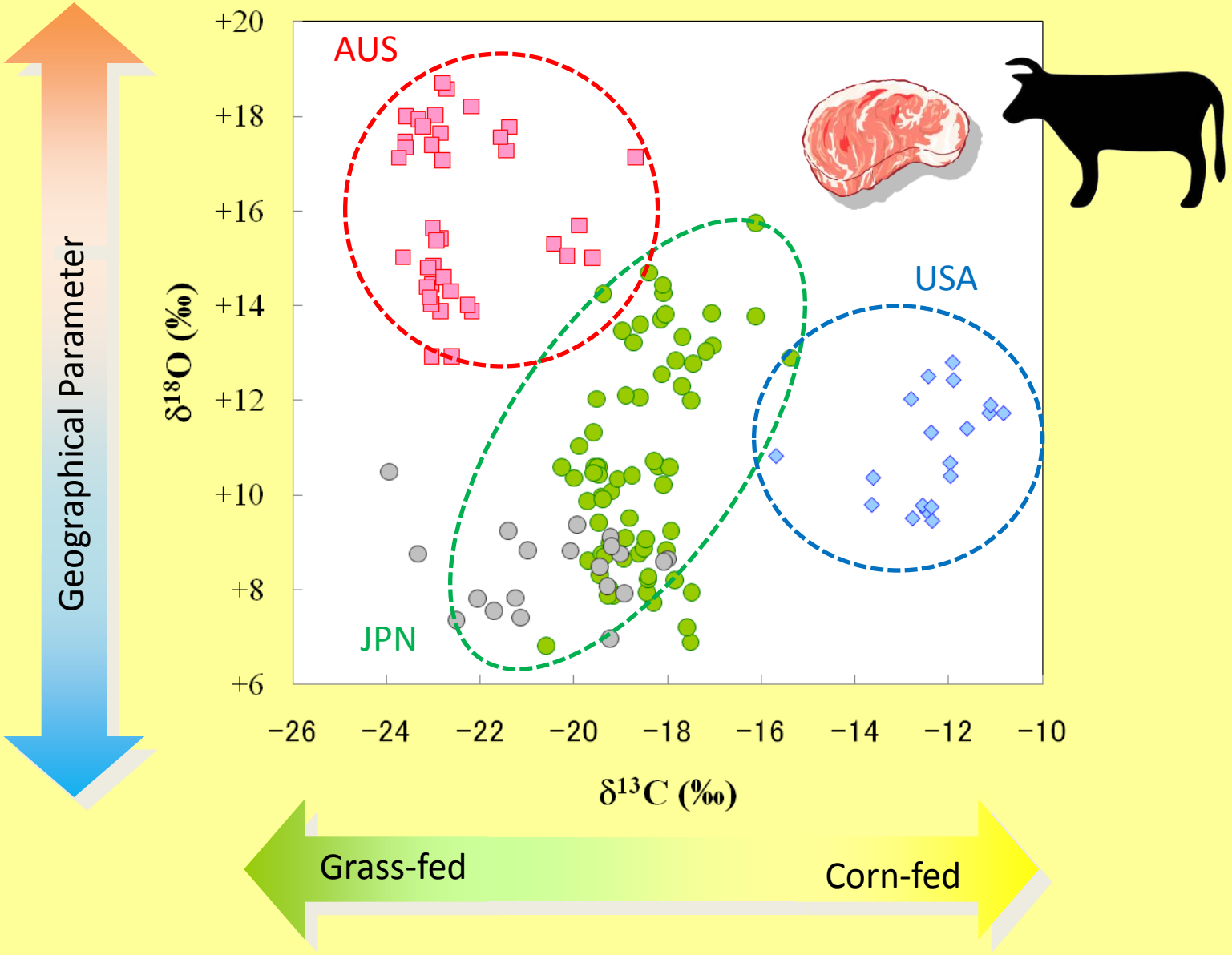
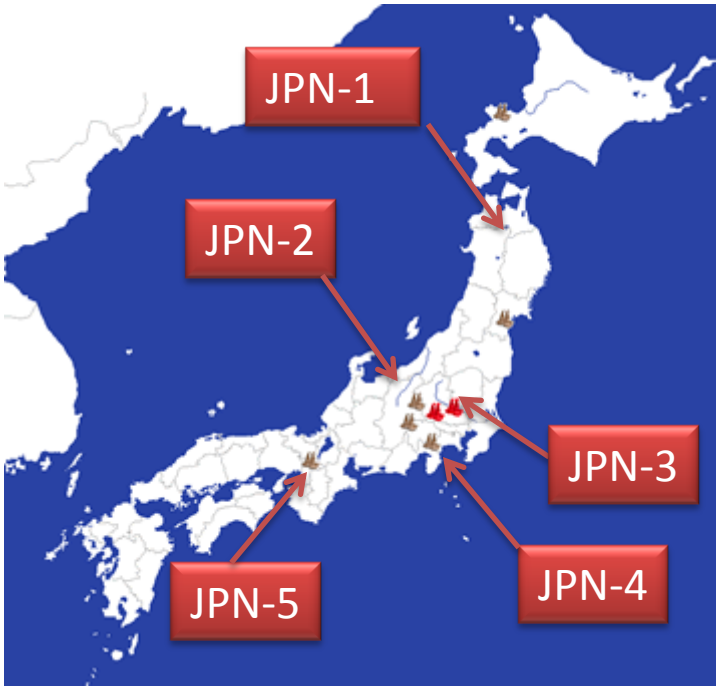
Case1: Geographical Origin of Beef

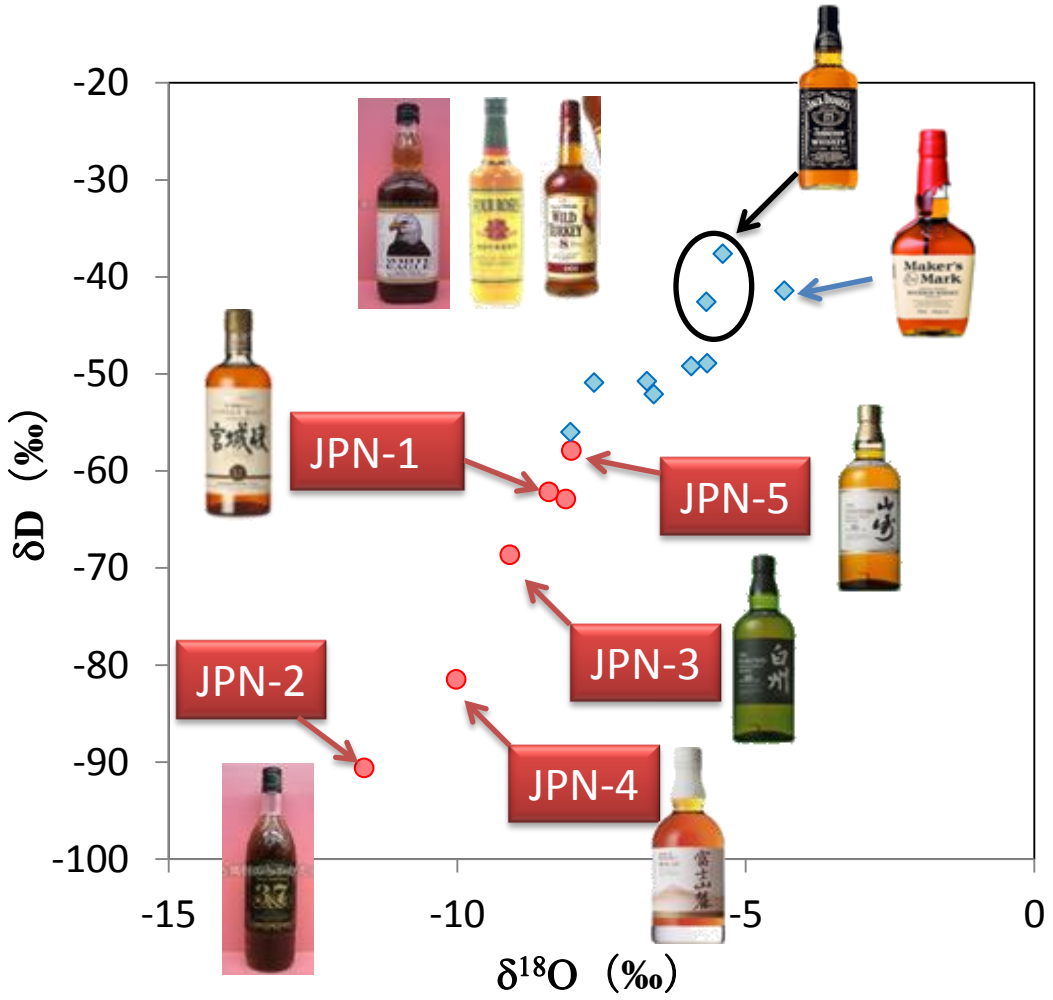


Case2: Geographical Origin of Whisky

Fake whiskies cost the industry approximate 10% in sales per year.

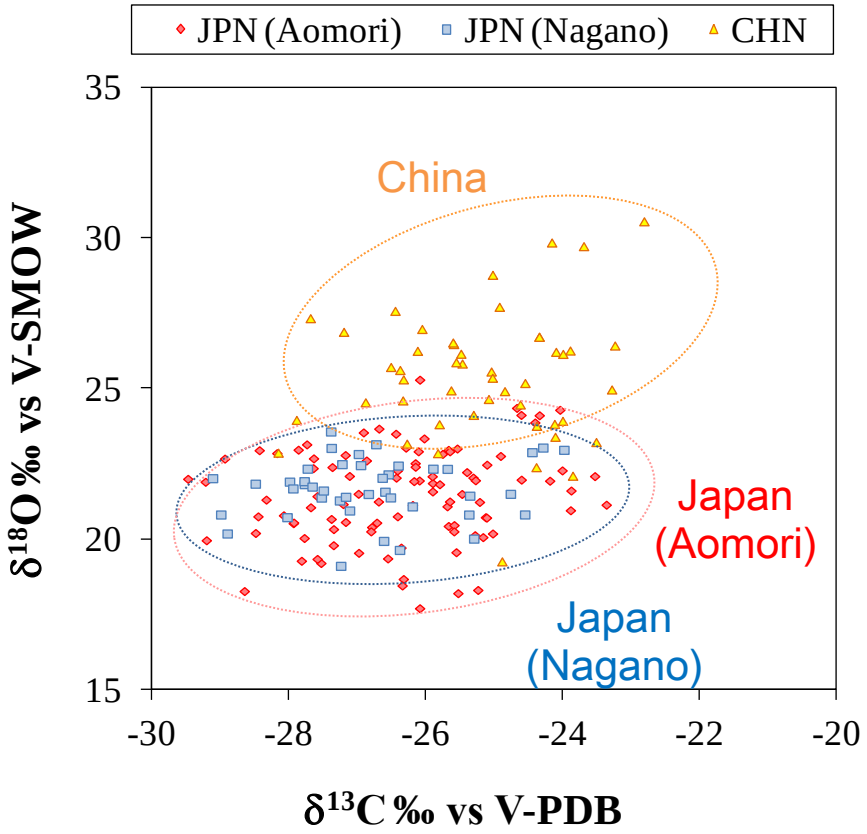
The local source water is used during whisky production.

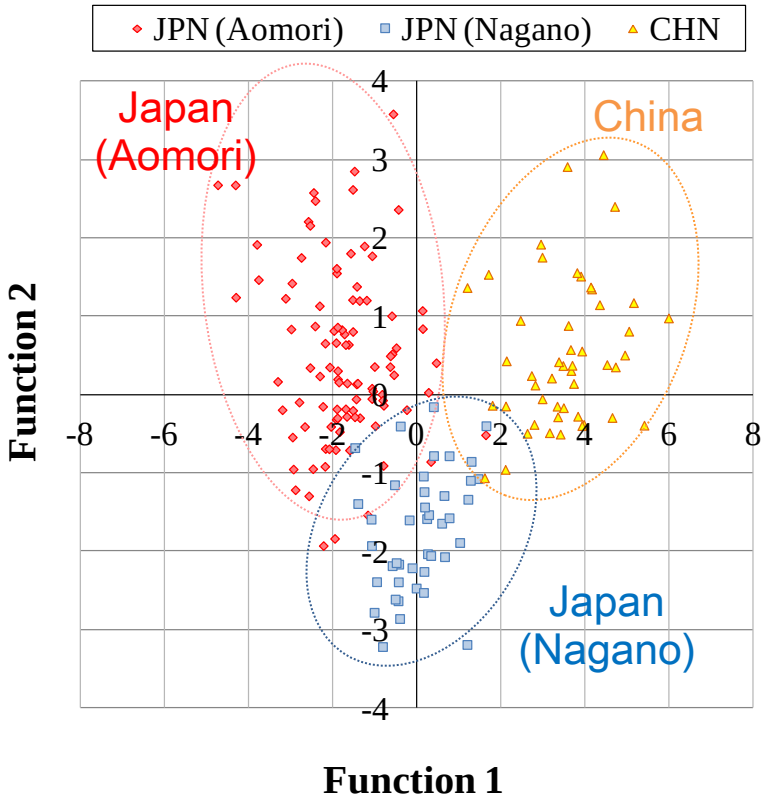




To improve the accuracy of discrimination of the geographical origin…

The combined use of multiple analytical methods is needed to improve the accuracy of discrimination of the geographical origin of agricultural products.





δ13C and δ18O

China:77%
Japan:96%

δ13C and δ18O + 9 elements

China:96%
Japan:99%

Thank you for your attention!