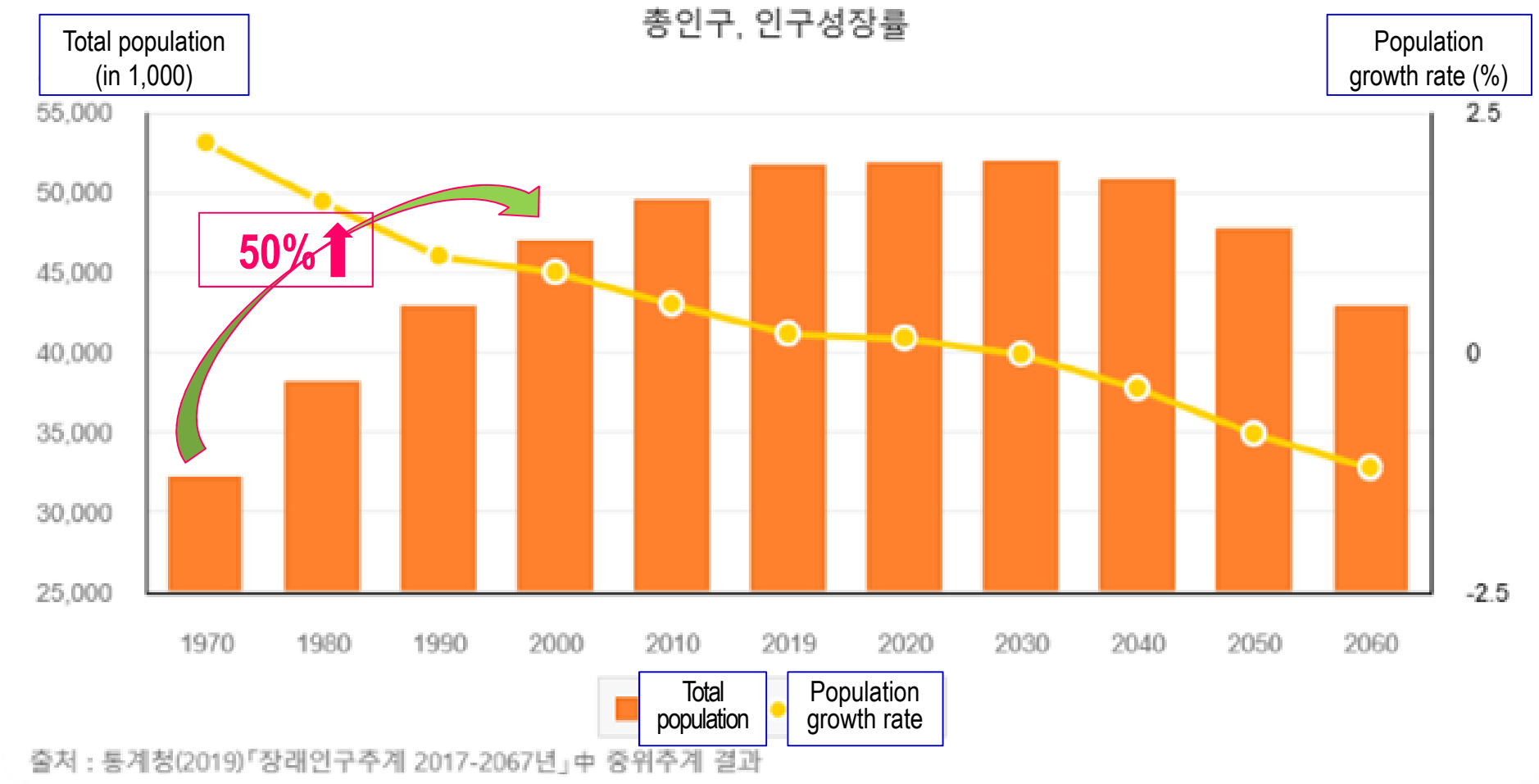
Total Diet Study in Korea:

Progress in last 2 decades and a way forward

Cho-il Kim

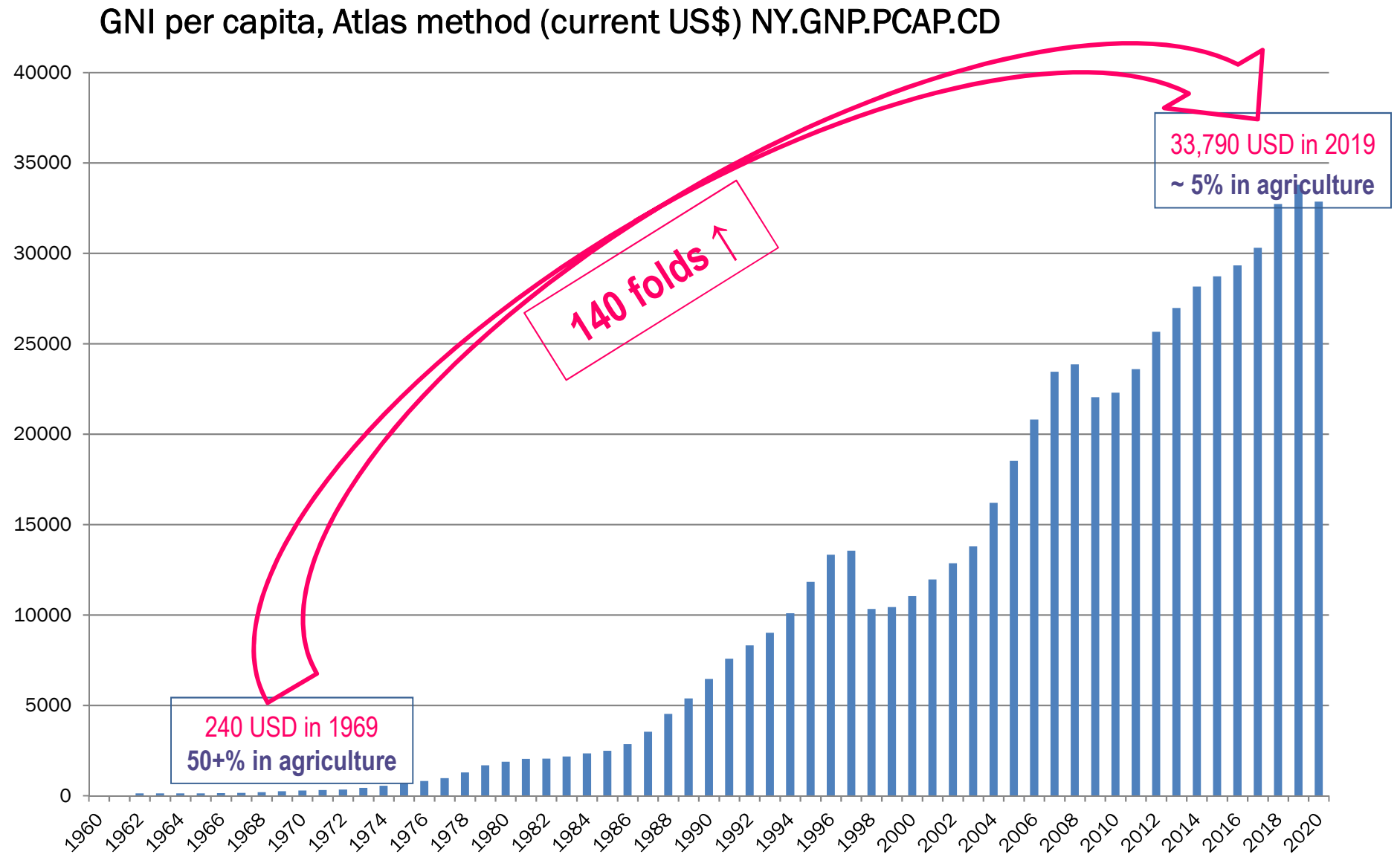
Seoul National University

Total Population Growth during 5 Decades in ROK

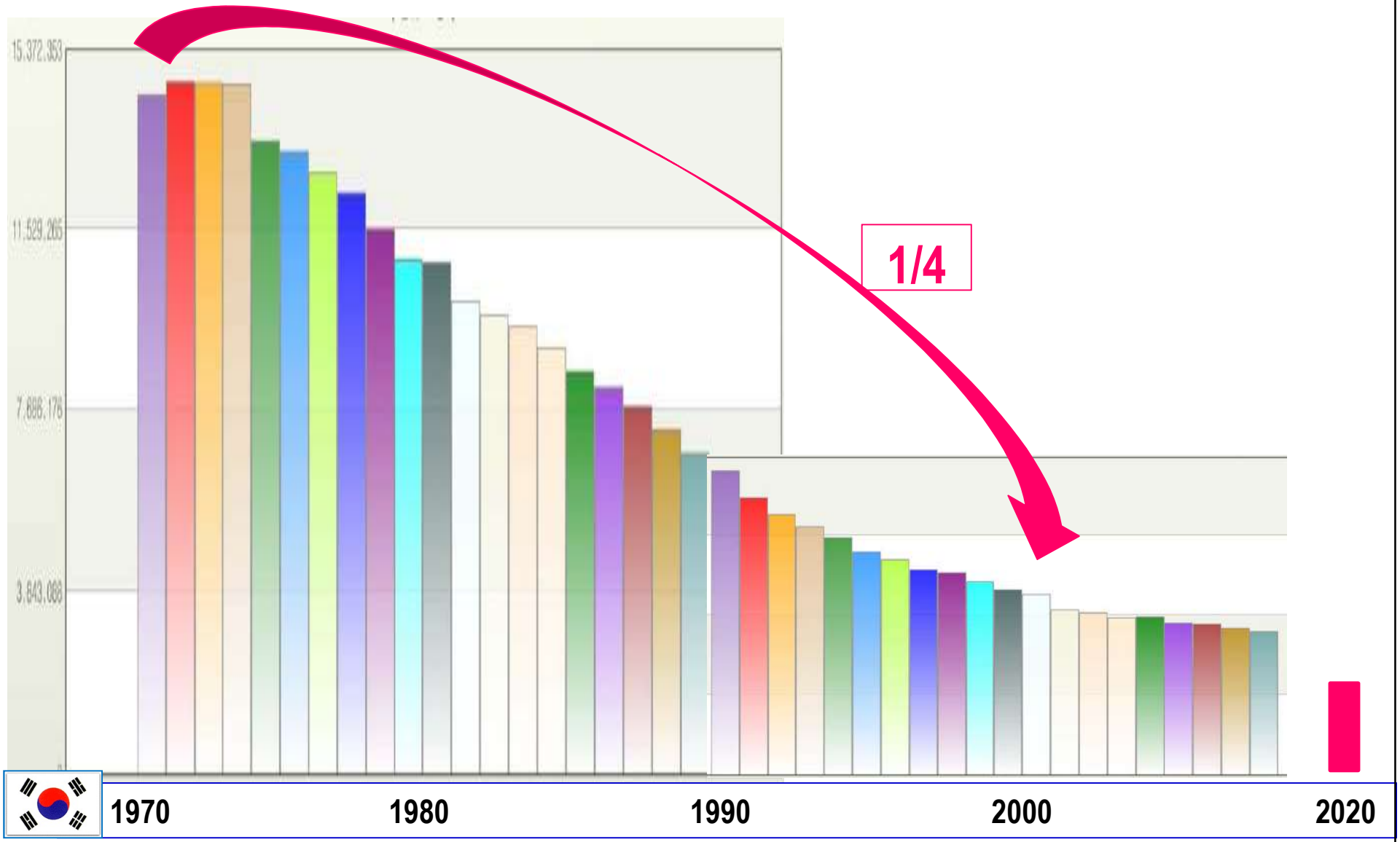


출처 : 통계청(2019)「장래인구추계 2017-2067년」中 중위추계 결과

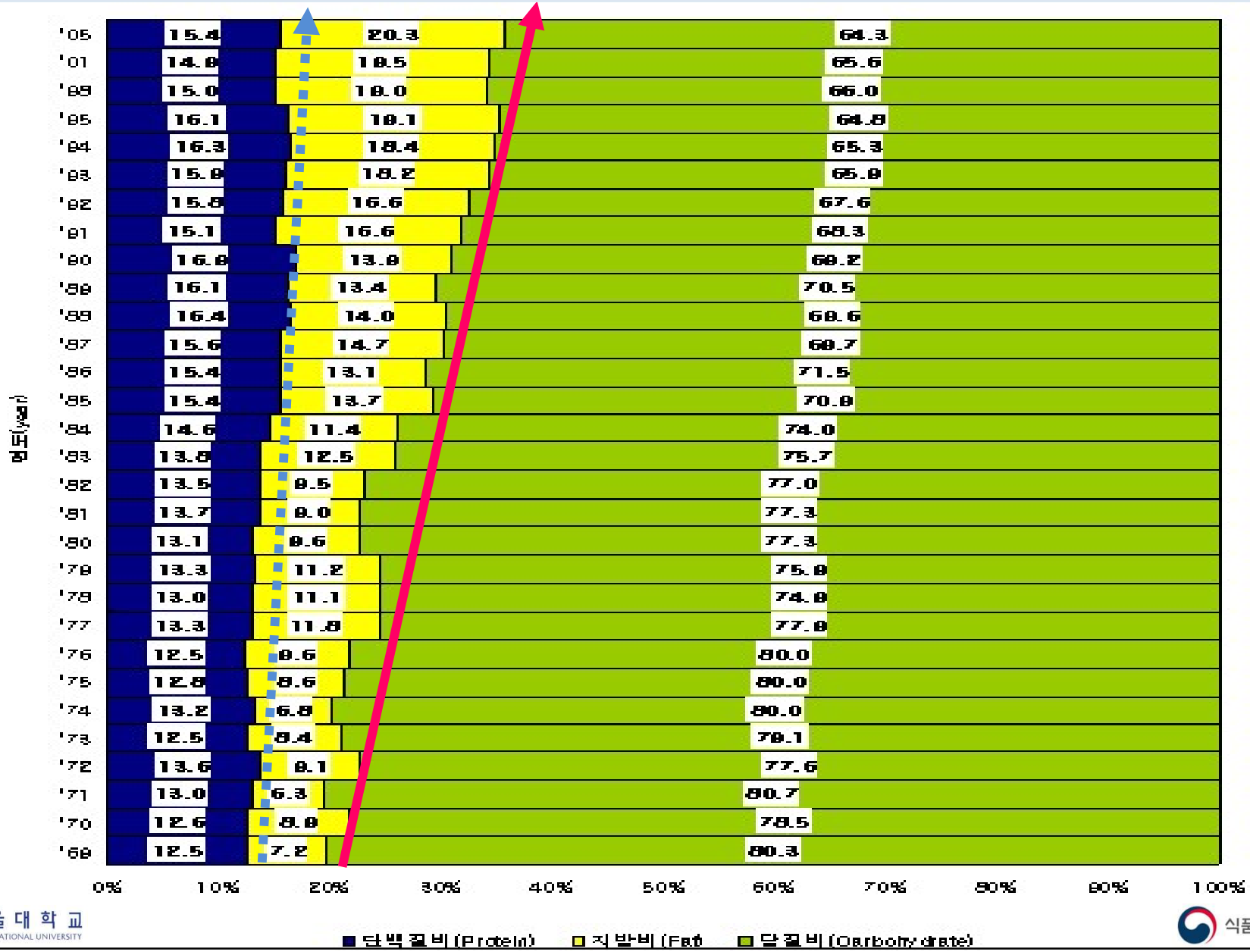
Leap in GNI per capita during last 5 decades in Korea



Change in Farm Population in Korea



Change in CHO/Protein/Fat Ratio in Energy Intake



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Hazardous Materials & Minerals Analyzed in Previous TDS

❖ Total Diet Study conducted intermittently under KFDA/MFDS

Group	Analytes	Year of TDS
Heavy metals	• As, Cd, Pb • As, Cd, Pb, Hg • As, Cd, Pb, Hg, Al • As, Cd, Pb, Sn, Hg, Me-Hg	1994 2000 ~ 2004 2005 ~ 2009, 2012 2016
Minerals	• Cu, Na, K, Ca, Zn, Fe • Mn, Cr, Cu, Fe, Ni, Zn • Mg, Na, K, Ca, Zn, Fe • Cu, Zn, Mn • Cr	1994, 2001 2000 2002, 2003 2004 2005~ 2009
Mycotoxin	• Aflatoxin B_1, M_1 • Aflatoxin B_1, B_2, G_1, G_2, M_1, Ochratoxin A, Fumonisin, Patulin, Deoxynivalenol, Zearalenone	2004 ~ 2006. 2012
Pesticides	• Alachlor, Amitraz, Dieldrin, Carbosulfan, etc. (196) • Carbendazim & others (104)	2002 2004
PCBs	• 62 PCBs, dl-PCBs, indicator PCBs • indicator PCBs (7)	2013, 2017
Processing/cooking contaminants	• Acyrlamide, PAHs, HCAs, Nitrosamines, Biogenic amines, Trans-fat, Aldehydes, Furan, Etylcarbamate, THMs, 1,3-DCP, 3-MCPD, Benzene, Etylene-oxide, etc.	2013 ~ 2016 2018 ~ 2021 2022 ~

National Health Promotion Act of 1995

Article 16 (National Nutrition Survey, etc.) (1) The Minister of Health and Welfare shall regularly conduct a national nutrition survey, such as the survey of health status of the citizens, intake of food and diet (hereinafter referred to as "national nutrition survey").
(2) A Special Metropolitan City, a Metropolitan City and a Do shall have public officials whose duties are to perform national nutrition surveys and nutrition guidance.
(3) The public officials who conduct national nutrition surveys shall produce identification indicating his/her authority to the persons concerned.
(4) The content of and method for the citizens' nutrition surveys and other matters necessary for the citizens' nutrition surveys and nutrition guidance shall be prescribed by Presidential Decree.

Triennial survey
Health exam on individuals
Dietary intake of individuals

CHAPTER Ⅲ NATIONAL HEALTH PROMOTION FUND
Article 22 (Establishment of Fund)
The Minister of Health and Welfare shall establish the National Health Promotion Fund (hereinafter referred to as the “Fund”) in order to assure a source of revenue necessary for the smooth promotion of the National Health Promotion Projects.
Article 23 (Appropriation of Fund) (1) The Fund shall be appropriated from the following sources of revenue:
1. Amount determined by the Ordinance of the Ministry of Health and Welfare from the sum of the money contributed to the public utilities works by the tobacco business operator and import-distributors referred to in Article 25-2 of the Tobacco Business Act;
2. Shared Money prescribed by the Presidential Decree within ten hundredths of the working expenses (including expenditures required as costs of Medical examinations) for preventive medical treatment of the insured referred to in the Medical Insurance Act and the Act on the medical Insurance for Public Officials and Private School Teachers and Staff; and
3. Other profits from the operation of the Fund.
(2) Computation basis and sharing method of the shared money referred to in paragraph (1) 2 shall be prescribed by the Presidential Decree.

National Food Intake Data Available as of 2022

1. Korea National Health and Nutrition Examination Survey (KNHANES)

- 1998 & 2001: November & December (KNHANES I & II)
- 2005: April & May (KNHANES III)
- *2007 (July-December), 2008, 2009 (KNHANES IV)*
- *2010, 2011, 2012 (KNHANES V)*
- *2013, 2014, 2015 (KNHANES VI)*
- *2016, 2017, 2018 (KNHANES VII)*
- *2019, 2020 (KNHANES VIII)*

2. KNHANES Seasonal Nutrition Survey

- 1999 & 2002: Spring, Summer, Fall
- 2005: Summer, Fall, Winter

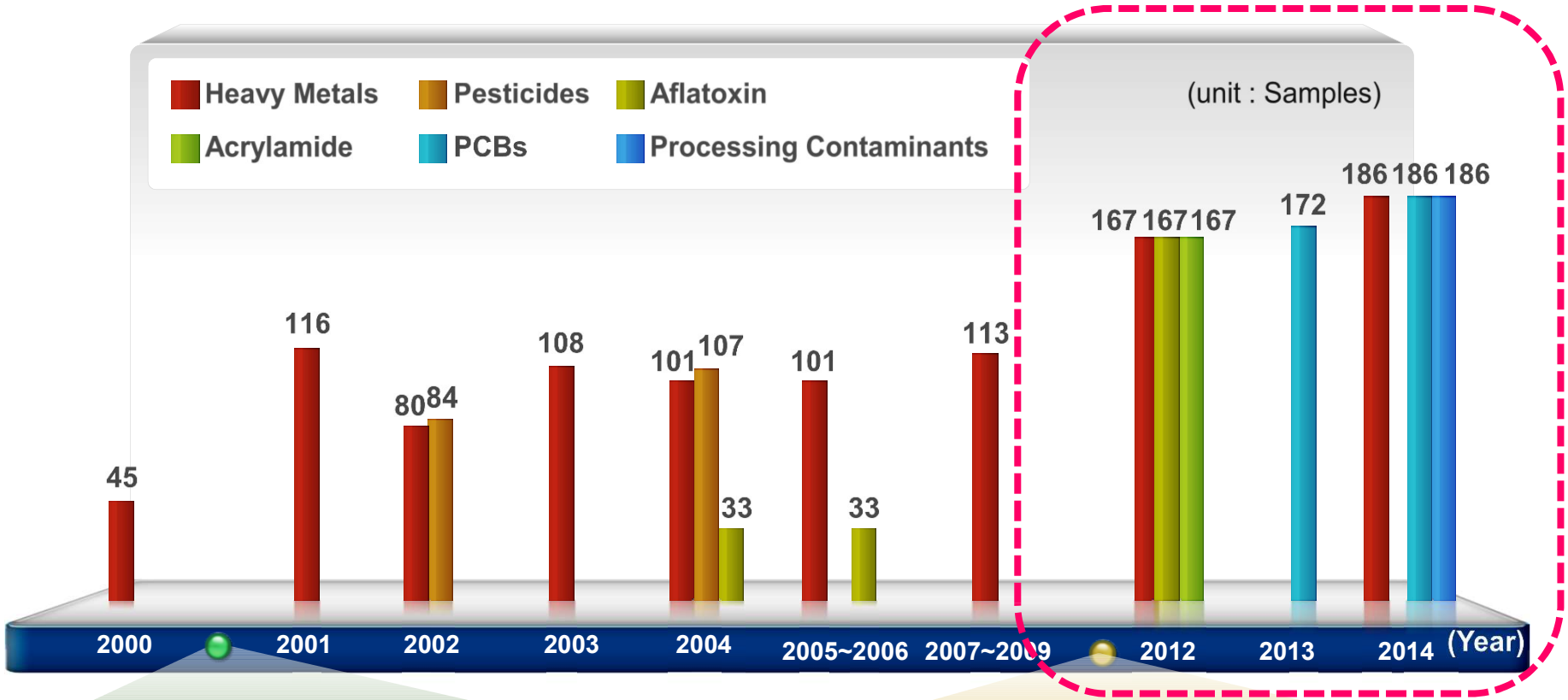
3. Special Dietary Intake Survey for Children

- 2007 Winter, 2008 Summer & Fall, 2009 Spring

4. Special Dietary Intake Survey for Infants, Pregnant & Lactating Women

- 2011 Winter, 2012 Summer & Fall, 2013 Spring

History of Total Diet Study (TDS) in Korea

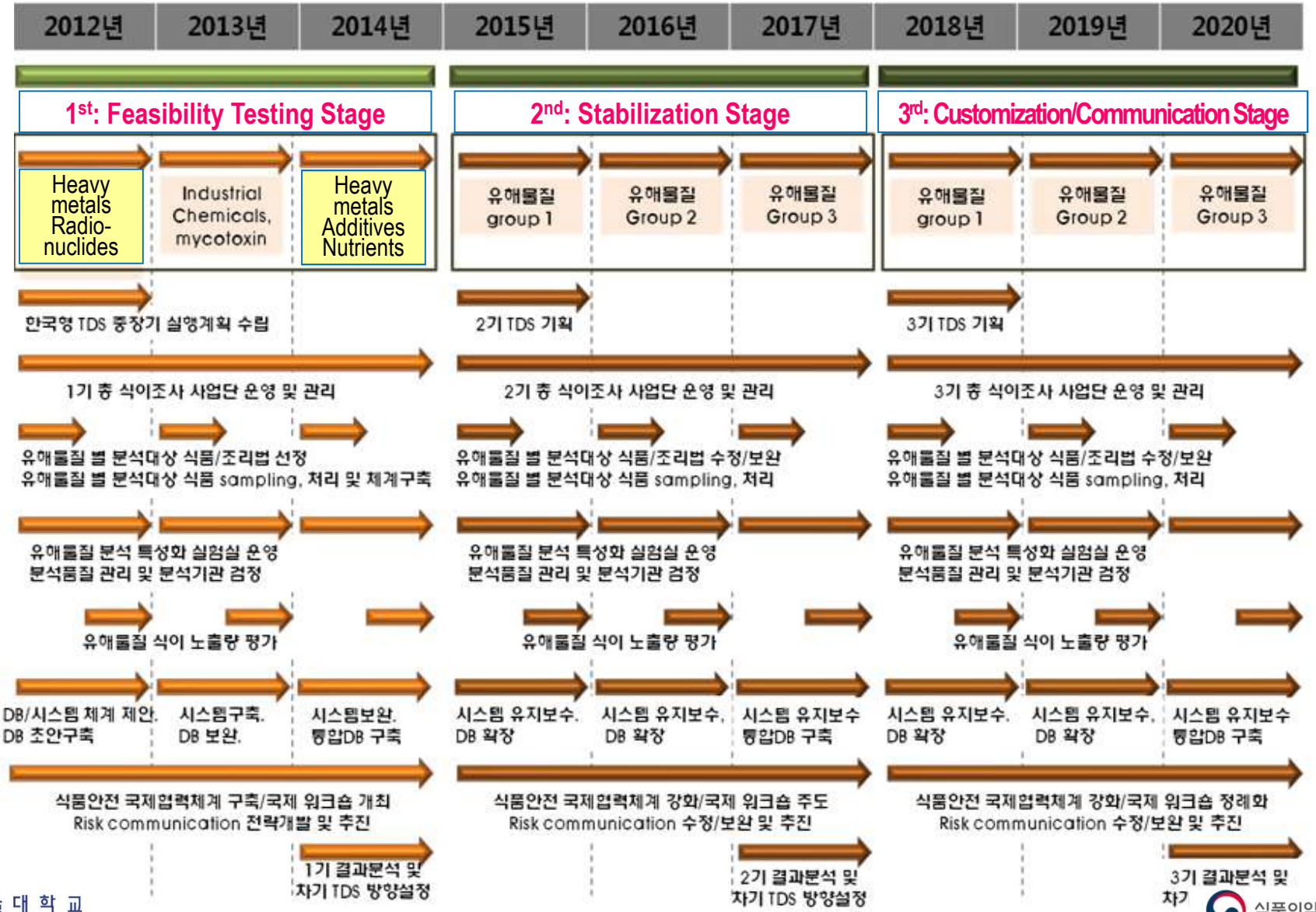


Menu (regional) → Market Basket

Establishment of TDS Master Plan

- **Increased analytes**
  - heavy metals, aflatoxins, pesticides(3 groups)
    → + POPs, Processing contaminants(27)
- **Expansion of food list : 114('09) → 186('14)**

2011 Master Plan: Mid-term Roadmap for Korean TDS



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Introduction of mapping for closer-to-real estimate

Nutrition Research and Practice (*Nutr Res Pract*) 2012;6(5):436-443
http://dx.doi.org/10.4162/nrp.2012.6.5.436
pISSN 1976-1457 eISSN 2005-6168

Measures for a closer-to-real estimate of dietary exposure to total mercury and lead in total diet study for Koreans

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Abstract

Previous Korean total diet studies (KTDSs) have estimated dietary exposure to toxic chemicals based on 110-120 representative foods selected from over 500 foods appeared in the Korea National Health & Nutrition Examination Surveys (KNHANES), which would result in a possible underestimation. In order to find measures for a closer-to-real estimate of dietary exposure to heavy metals, this study examined the feasibility of mapping foods to the representative foods in the KTDS by comparing estimates. In mapping, those foods not analyzed in the 2009 KTDS (443 out of 559 foods appeared in the 2007 KNHANES) were mapped to the 114 representative foods used in the 2009 KTDS based on the closeness in regards to biological systematics and morphological similarity. Dietary exposures to total mercury and lead were re-estimated using the content of total mercury and lead in 114 foods analyzed in the 2009 KTDS, food intake, and individual's own body weight for respondents in the 2007 KNHANES instead of mean body weight of Koreans used in the 2009 KTDS. The re-estimates of exposure with mapping were approximately 50% higher than the original estimates reported in the 2009 KTDS. In addition, mapping enabled the comparison of percentile distribution of the exposure among populations of different age groups. In conclusion, estimates via mapping resulted in a more comprehensive estimation of dietary exposure to heavy metals present in foods that Koreans consume.

Key Words: Dietary exposure, total mercury, lead, mapping, Korean total diet study (KTDS)

Total Diet Study as a R&D Project (2013-2016), Securing Legal Basis, and Guides Development

Foods and hazardous materials: processing contaminants

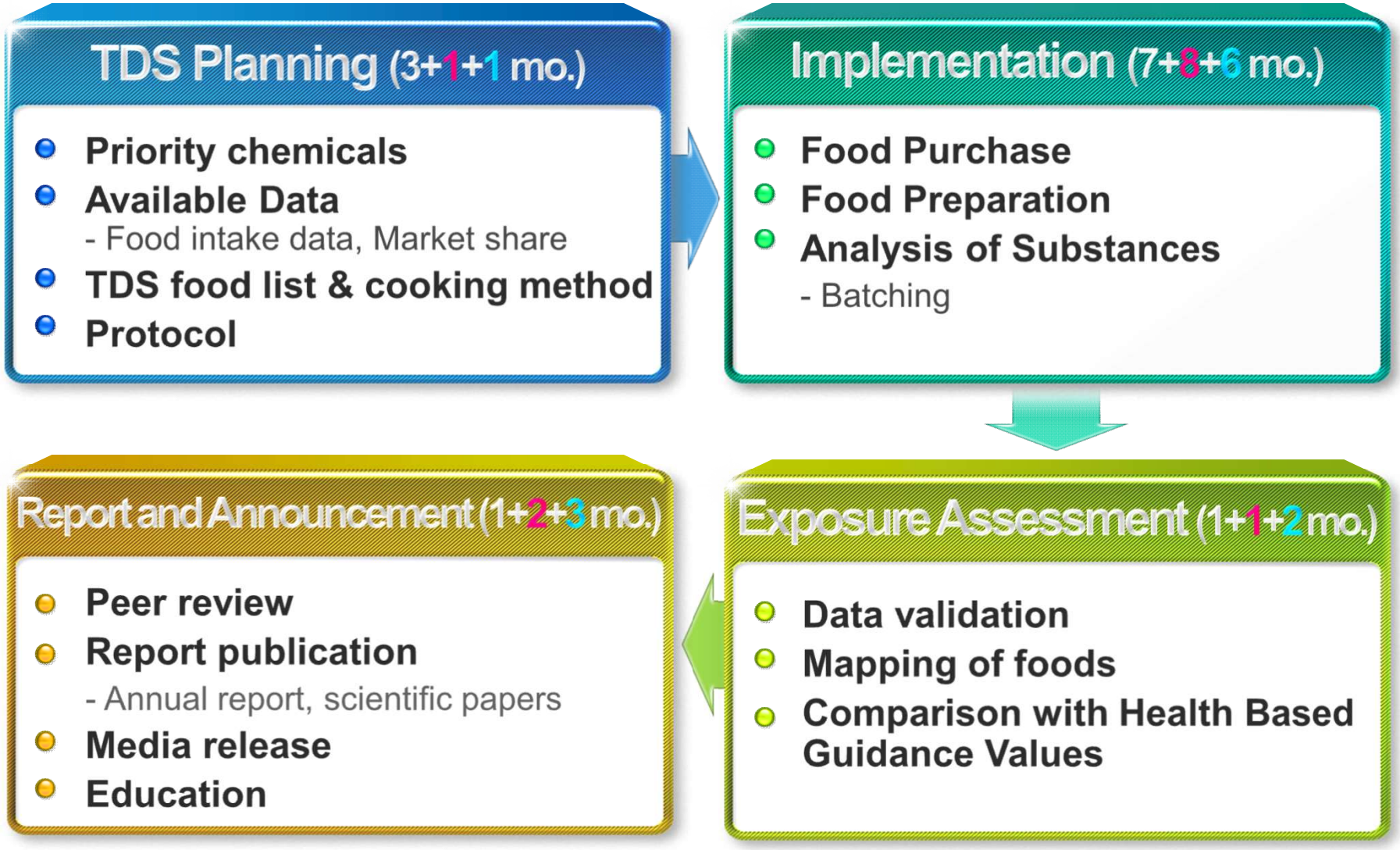
Foods for analysis

Study 1

- Crops and products (1st year)
- Meats and products (2nd year)
- Seafood & products (3rd year)

Analytes	Study 3	Study 4	Study 5	Study 6
	• Benzo pyrene • Polycyclic hydrocarbon • 3-Methyl cholanthrene • Acrylamide • Hetero-cyclic amines • 2-amino-2,8-dimethyl imidazo (4,5-f) quinoxiline • 12-Amino-3-methyl imidazo (4,5-f) quinoline	• Trans fats • Furan • Acetaldehyde • Formaldehyde	• Ethylene carbamate • Biogenic amines • Histamine • Nitroso-dimethyl amine • Nitroso-piperidine • Nitroso-diethyl amine • Nitroso-pyrrolidine • Nitroso-dibutyl amine • Nitroso-semophorine	• Ethylene oxide • Tri-halo methane • 1,3-Dichloropropanol • 3-MCPD • Benzene
Labs	KIST KIAT Dongkuk University	Dongkuk Univ. KFRI Ewha Women's Univ.	Seoul National University Korea University Seoul Women's University	KIST

Flow and time allowed in 2013-2016 TDS (3 rounds in 3 years)



Legal Basis: Food Sanitation Act (FSA) Amended

Article 7-4 (Management Plans, etc. of Standards and Specifications of Foods, etc.)

(1) The Minister of Food and Drug Safety may formulate and promote a master plan for management of standards and specifications of foods, etc. (hereinafter referred to as "management plan") **every 5 years**, subject to consultations with the heads of related central administrative agencies and deliberation by the Food Sanitation Deliberative Committee under Article 57.

(2) A management plan shall include the following:

1. Basic objectives and directions for implementation of the management of standards and specifications of foods, etc.;
2. Evaluation of the amount of exposure of foods, etc. to harmful substances;
3. A plan for appropriate management of the total amount of exposure of foods, etc. to harmful substances;
4. Matters concerning reevaluation of standards and specifications of foods, etc.;
5. Other necessary matters concerning the management of standards and specifications of foods, etc.

(3) In order to implement a management plan, the Minister of Food and Drug Safety shall formulate an action plan for management of standards and specifications of foods, etc. (hereinafter referred to as "action plan") every year in consultation with the heads of related central administrative agencies.

(4) When necessary to formulate and implement a management plan and an action plan, the Minister of Food and Drug Safety may request the heads of related central administrative agencies and local governments to provide cooperation. In such cases, the heads of related central administrative agencies, etc. that are requested to provide cooperation shall comply therewith unless extenuating circumstances exist.

(5) The types of harmful substances subject to the evaluation and management of the amount of exposure included in a management plan, and matters necessary for the formulation, implementation, etc. of a management plan and an action plan shall be prescribed by Ordinance of the Prime Minister.

[This Article Newly Inserted by Act No. 12719, May 28, **2014** and effective from November 29, **2014**]

Article 7-5 (Reevaluation, etc. of Standards and Specifications of Foods, etc.)

(1) The Minister of Food and Drug Safety shall reevaluate standards and specifications pertaining to foods, etc. in accordance with a management plan in a periodic manner.

(2) Necessary matters concerning objects, methods of and procedures for reevaluation under paragraph (1) shall be prescribed by Ordinance of the Prime Minister.

[This Article Newly Inserted by Act No. 12719, May 28, **2014** and effective from November 29, **2014**]

Legal Basis: Amended FSA - Ordinance of PM

Article 5-4 (Establishment and Implementation of Standards and Specifications for Basic Management of Food, etc.) [This Article Newly Inserted, August 18, 2015]

(1) The types of hazardous substances to be the targets in the evaluation and management of the exposure included in the basic plan (hereinafter referred to as "management plan") for management of standard and specifications of foods, etc. are as follows

1. Heavy metals
2. Mycotoxins
3. Organic pollutants
4. Pollutants produced during manufacturing and processing
5. In addition, hazardous substances that the Minister of Food and Drug Safety deems necessary to evaluate and manage exposure for the safety management of food, etc..

(2) When establishing and implementing the management plan and the implementation plan of standards and specifications of foods, etc. pursuant to Article 7-4 (3) of the Act, the following data shall be used as a basis.

1. Data on degree of contamination of harmful substances in food, etc.
2. Data on the reduction (reduction) of harmful substances in food, etc.
3. Data from **Total Diet Study (TDS)**
4. Data from Nutrition & Dietary Survey according to Article 7 (2) 2 C of the 「National Nutrition Management Act」 ⇒ KNHANES data

Preparation of Food Samples in Korean TDS

▶ Guide Manual for Sample Preparation in Korean Total Diet Study

Published in 2016

한국형 총식이조사 표준지침서

Guidebook for Korean Total Diet Studies

○ Guide for Korean Total Diet Studies

- A step-by-step guide was developed to promote TDSs in consistent and comparable manner
- A total of 18 basic phases was suggested from planning through risk communication in Total Diet Studies
- Wherever possible, detailed examples were provided to enhance understanding and promote proper conducting of TDSs by food safety control related professionals with some experience

○ Guide for Food Intake Survey of Koreans

- To accommodate the information needs in TDSs, a step-by-step guide was developed for food intake survey on the population of interest
- Procedures from the planning through data management were described in 10 chapters based on the survey design of the Korea National Health and Nutrition Examination Survey

○ Guide for Chemical Analysis and Quality Control involved in Total Diet Studies

- Guide for chemical analysis of hazardous materials and nutrients
- Guide for quality control (QC) and quality assurance (QA) of chemical analysis in the designated laboratories and relevant data

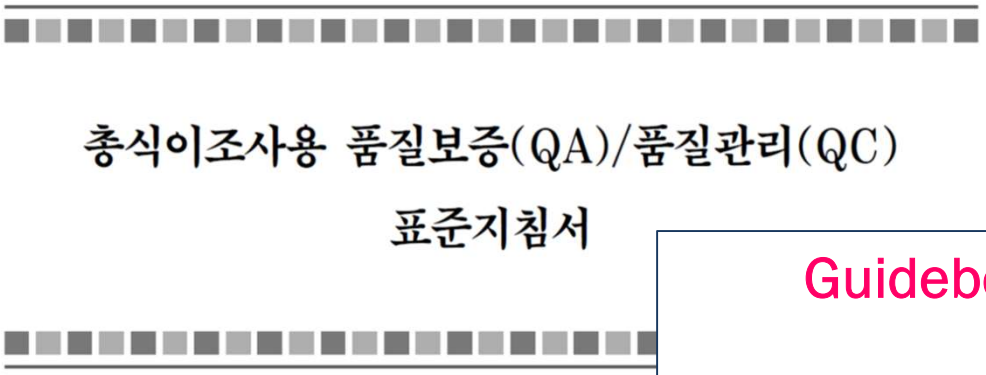
○ Suggestions for Simultaneous Assessment on Food-driven Risk & Benefit

- Some examples from foreign countries
- Comparison and analytic discussion on food-driven exposures to hazardous materials and some nutrients based on the domestic data

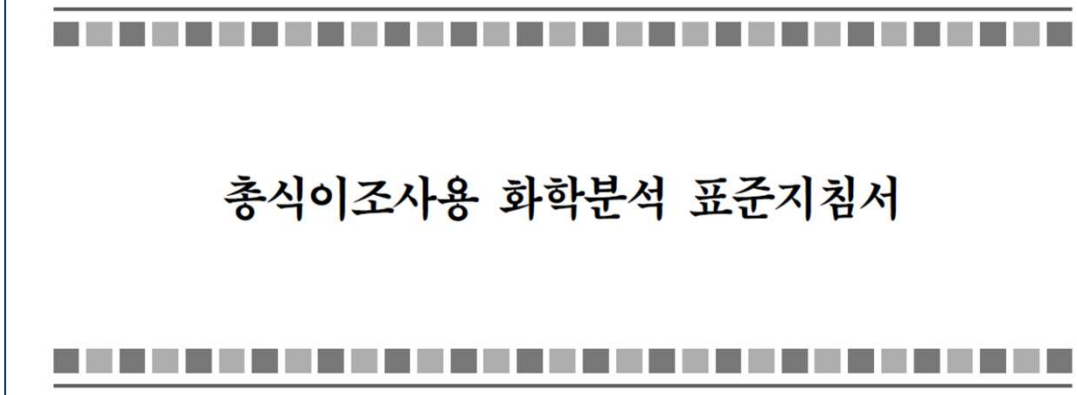
Published in 2017

Guidebooks for Korean Total Diet Study

Guidebook for QA and QC in Chemical Analysis for Total Diet Studies in Korea



Guidebook for Chemical Analysis: Total Diet Studies



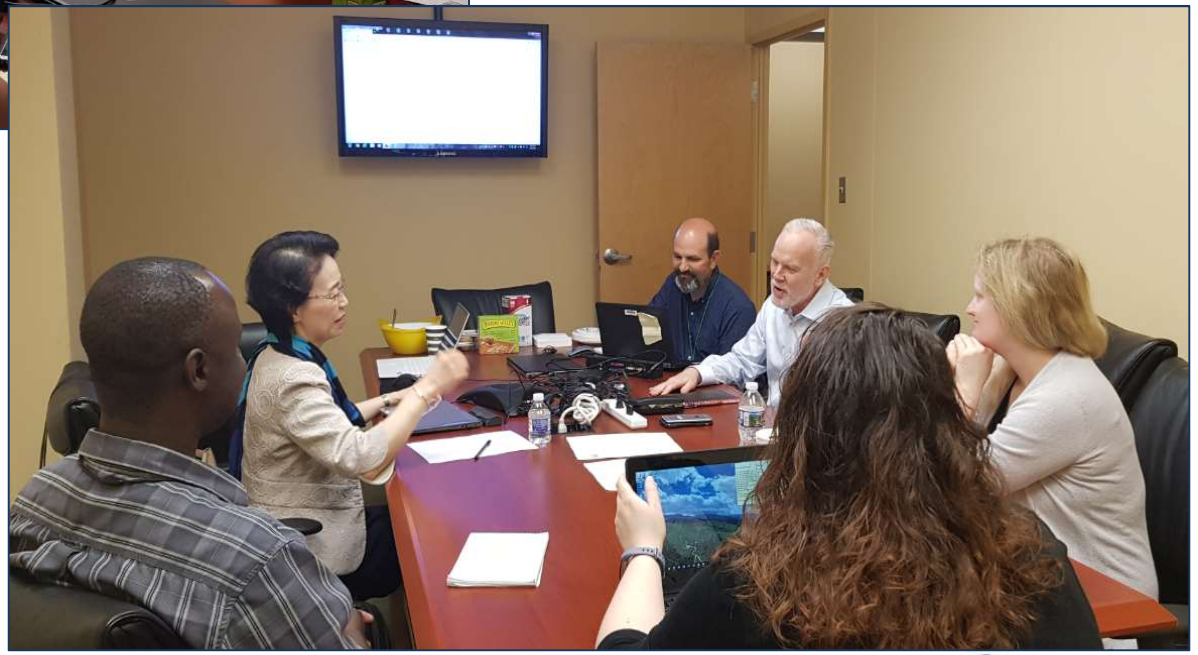
Learning from Peers for Korean Total Diet Study

Issue: How to handle data w/NDs

- **Statistical approach** needed to handle data with considerable portion of 'Not Detected' values in estimating exposure to hazardous materials

  - Deterministic exposure estimation has been mostly used with simple mean and 0 for NDs (lower bound) in Korea
  - In the R&D project TDS, only 1 composite sample per food was used for analysis along with individual intake data of population to mimic probabilistic estimation
  - WHO recommends to secure 30-50 analysis samples per food for HM analysis with low detection rates for statistical treatment of NDs
  - US FDA is piloting with 24 samples per food from 2017

Duty Travels to US FDA CFSAN till 2016 & 2019



Duty Travel to BfR in 2017

DUTY

Korea Hea

Sequence of the BfR MEAL Study

Step 1 | Step 2

Selection of foods | Purchase throughout Germany

Potatoes | Rösti | French fries

Cooking

Analysis in t

Couriers transport the samples to the la
analysed for nine substance groups – i
additives and substances migrating fro

– TDS Kitchen for BfR M

BfR 정문

수집 시료 반입 공간

TDS Kitchen 현관

Walk–in Cold room

Sample preparation Room 입구

Sample preparation Personnel

Prepared Samples

Prepared Sample Homogenization Room

Prepared Sample Homogenization Room

Deionized Water for Sample Homogenization

Homogenized Samples

Homogenized Samples

Homogenized Samples for Different Seasons

Utensil Washing Room

Utensil Washing Room

Sample Collection Vehicle (냉장 가능)

Prepared Samples

Prepared Sample Homogenization Room

bar–code reader

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The 1st Korean Total Diet Study (2018-2022)

※ Acknowledgement: The 1st Korean Total Diet Study has been funded by the Ministry of Food & Drug Safety (MFDS).

Korean Total Diet Study: Objectives

- Estimation of dietary exposure for heavy metals and mycotoxins which are the priority components for Standards & Specification for Food Safety in Korea through TDS
- Estimation of dietary intake for some nutrients of concern in total population and/or certain age groups, such as vitamin D, calcium, and iron
  - The Guide Manual for Korean Total Diet Study published in 2017 by MFDS needs to be used throughout the study along with the Guide Manuals for Chemical Analysis, QA & QC, and Sample Preparation in Korean Total Diet Study
- Stabilized planning and execution of TDS based on the representative & credible data

Flow of the Korean Total Diet Study (2018-2022)

Selection of representative foods for TDS

Sub-study 1
- Planning
- RF selection
- Prep. Method selection

- RF coverage: 90% or more
- Reflecting change in diet
  - Most recent KNHANES

Food sample collection & preparation

Sub-study 1
- RF sample collection
  - by Region/season
- Sample preparation
  - Dispatch to labs (S2 &S 3)

- 6 sample composite /RF
- Total 1,200 ~ 1,500 analysis samples
- Standard Guide Manual for sample preparation

HM/Nutrient analysis (S 2& 3)

- Setting/validation of method
- Data Validation
- HMs/Nutrients analysis

Study 2
- Mycotoxins

Study 3
- Heavy metals
- Nutrients

- Standard Guide Manual for Chemical Analysis in TDS
- Standard Guide Manual for QA & QC for TDS

Total exposure estimation of HMs/Nutrients

Sub-study 1
- Mean/distribution of intake
- Exposure estimation
- Risk/benefit comparison
- w/ & w/o mapping

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Representative Food Selection for Korean TDS: Year 1

- Merged intake data from 2013 through 2016 KNHANES
- Food list at tertiary (3°) food code level
  - In line w/ principles for Standards & Specifications: 555 items
- Deleted NA foods for S&S (ex. broth): 547 items
- Intake of dried foods in KNHANES -> Conversion to raw state amount
  (based on the factors given in KNHANES data)
  - ∵ S&S set based on raw state of foods
- List to cover at least 90% of total food intake: 100 items
  - Based on population mean intake of each food item at 3° code level
- Addition of food items consumed in low amount but w/ higher frequency
  - Items w/ frequency > 33.3% (seasonings): 7 items ⟹ Total of 107 items

Representative Food Selection for Korean TDS: Year 1

▶ More addition for mapping feasibility: systematic similarity

- Items w/ frequency ≥ 5.0% among those belong to the cumulative intake proportion of 90~95%: 15 items including mushrooms

▶ Addition of items known for high content of heavy metals: 6 items

- Octopus, crab, beef byproducts, mussels, oysters, scallops

▶ Addition of items of concern for mycotoxins: 2 items

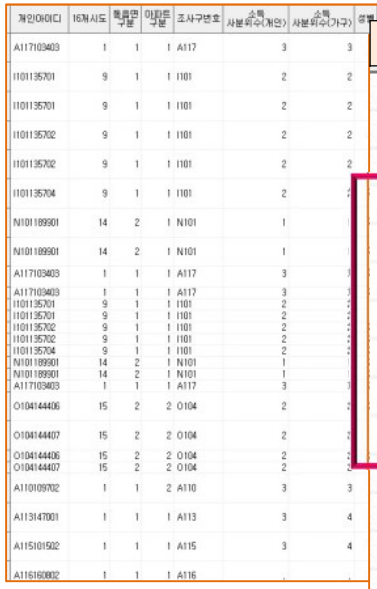
- Breakfast cereals, dried & ground red pepper (2° 。 Food code level)

129 items at 3° code level and 1 item at 2° code level

Total of 130 items covering 92.8% of total food intake

Ingredient food intake estimated from recipe data

Raw data from Nutrition Survey of KNHANES



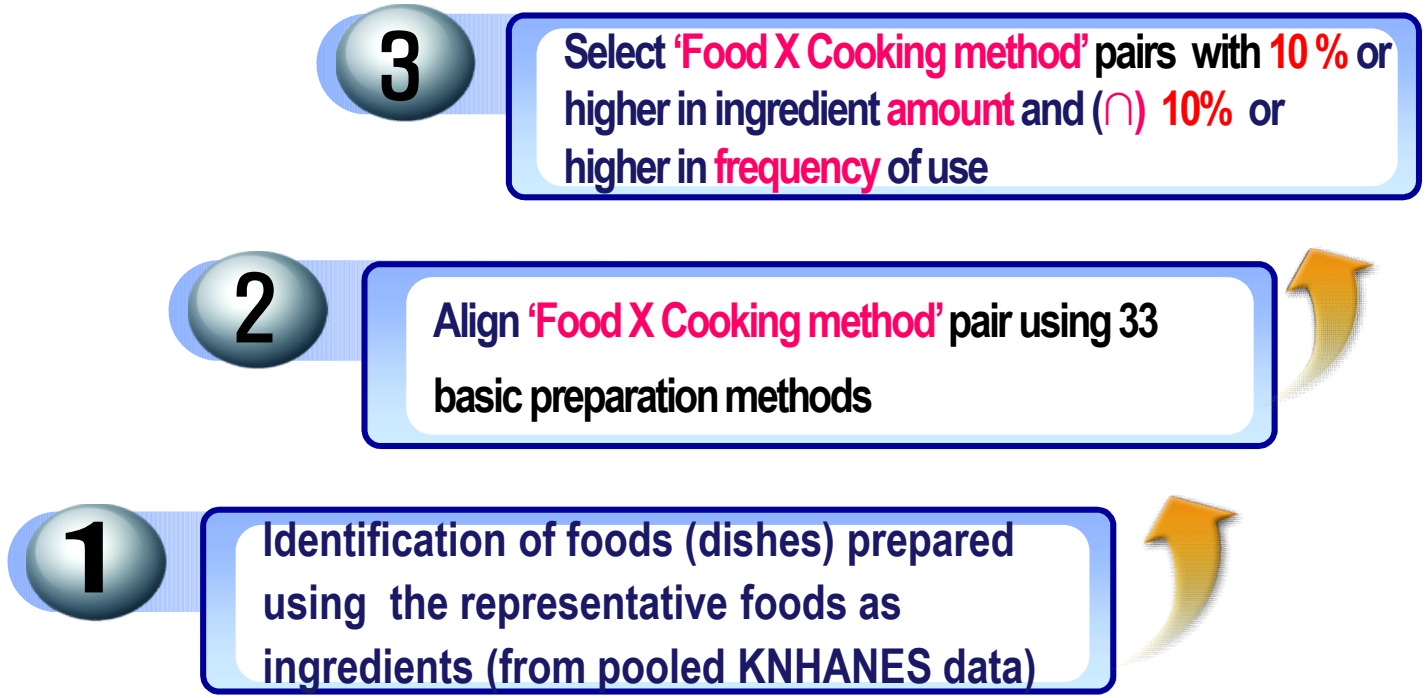
Subject ID	Name of dish	Dish code	Food code	Name of food	Intake
A101100102	쌀밥	10136	01173	쌀,멥쌀,논벼,백미,국내산,일반형	234.97
A101100102	쌀밥	10136	01173	쌀,멥쌀,논벼,백미,국내산,일반형	234.97
A101100102	초코파이	50253	01099	밀 및 밀가공식품 빵/과자류 초코파	68.00
A101100102	Squash & Tofu Stew	70520	04017	tofu	26.56
A101100102	Squash & Tofu Stew	70520	06034	green peppers	1.74
A101100102	Squash & Tofu Stew	70520	06121	garlic	0.74
A101100102	Squash & Tofu Stew	70520	06388	green onions	3.94
A101100102	Squash & Tofu Stew	70520	06407	young squash	8.72
A101100102	Squash & Tofu Stew	70520	11164	Anchovy	1.74
A101100102	Squash & Tofu Stew	70520	16018	Soybean paste	8.72
A101100102	삼겹살	70840	09085	돼지고기,고기,삼겹살,생것	129.34
A101100102	삼겹살	70840	16038	소금,식염	2.29
A101100102	계란후라이	10915	10005	달걀,전란,생것	50.00
A101100102	계란후라이	10915	10005	달걀,전란,생것	50.00
A101100102	계란후라이	10915	14017	옥수수기름	2.00
A101100102	계란후라이	10915	14017	옥수수기름	2.00
A101100102	계란후라이	10915	16038	소금,식염	0.75
A101100102	계란후라이	10915	16038	소금,식염	0.75
A101100102	잔멸치볶음	11060	03024	설탕,백설탕	0.84
A101100102	잔멸치볶음	11060	03024	설탕,백설탕	0.84
A101100102	잔멸치볶음	11060	05061	참깨,흰깨,볶은것	0.13
A101100102	잔멸치볶음	11060	05061	참깨,흰깨,볶은것	0.13
A101100102	잔멸치볶음	11060	06121	마늘,구근,국내산,생것	0.32
A101100102	잔멸치볶음	11060	06121	마늘,구근,국내산,생것	0.32
A101100102	잔멸치볶음	11060	11166	멸치,잔멸치,자건품	3.02
A101100102	잔멸치볶음	11060	11166	멸치,잔멸치,자건품	3.02
A101100102	잔멸치볶음	11060	14017	옥수수기름	0.51

Basic preparation (cooking) methods for RFs

	Preparation	Example
1	roasted/grilled	beef
2	as is/raw	strawberry
3	pan fried	wheat flour
4	pan fried and boiled	tofu
5	blanched/parboiled	spinach
6	blanched and pan fried	bean sprouts (mung bea
7	blanched and steamed	cabbage (wonton)
8	blanched and boiled	bean sprouts (wonton in
9	blanched and stir fried	perilla leaves
10	boiled	kimchi (stew)
11	boiled water added	powdered infant formula
12	boiled and taken out (use liquid)	dried anchovy
13	Steamed (rice)	white rice
14	Steamed (rice) and boiled	rice (rice in soup)
15	Steamed (rice) and stir fried	fried rice
16	Steamed (rice) and pan fried	rice (scorched rice)
17	stir fried	Vegetables

	Preparation	Example
18	stir fried and pan fried	mushroom (omelet)
19	stir fried and simmered	beef (spaghetti sauce)
20	soaked in water	dried seaweed
21	soaked in water and boiled	dried seaweed (soup)
22	soaked in water and stir fried	dried fern/bracken
23	boiled and strained (use solid mass)	pork
24	boiled, strained and baked	spaghetti (oven)
25	boiled, strained and boiled	noodles (stew)
26	boiled, strained and stir fried	spaghetti
27	boiled, strained and pan fried	pork (mungbean pancake)
28	boiled, strained and steamed	starch noodle (wonton)
29	boiled, strained and fried	starch noodle (wonton)
30	steamed	corn
31	steamed and fried	wonton (fried wonton)
32	steamed or baked	sweet potato
33	fried	potato (French fries)

Representative preparation methods for Korean TDS



Representative preparation methods for Korean TDS

▶ Addition of 6 cooking methods used for foods w/ relatively high intake,

- 'Food X Cooking method' pairs with 5 % or higher in ingredient amount and (∩) 10% or higher in frequency of use
- 'Food X Cooking method' pairs with 10 % or higher in ingredient amount and (∩) 5% or higher in frequency of use: ex. tofu

Food Code	Name of Food	Mean Intake (g)	Cooking method used	5% ∩ 10%	10% ∩ 5%
09070	Pork	41.7	Frying		○
10005	Eggs	29.7	Boiling		○
06029	Pepper	27.5	Stir-frying		○
02001	Potatoes	21.3	Frying		○
09135	Beef	21.8	Stir-frying		○
04017	Tofu	20.2	Pan-frying	○	

Representative preparation methods for Korean TDS

▶ Limit number of preparation methods for food w/ lower intake amount

- When 3 or more prep. methods were selected for foods w/ intake < 1.5g, allow only 2 methods based on ingredient amount and frequency of use

▶ Integration of some preparation methods into one or deletion

- Integration of 'stir fried & simmered' and 'boiled' into 'boiled'
- Deletion of 'pan-frying' if both 'stir-frying' and 'pan-frying' were selected

▶ Selected preparation methods

- For 130 items, 224 pairs of 'Food X Cooking Method' were selected

Sampling Sites for Representative Foods

▶ 3 Regions and 3 metropolitan cities/region

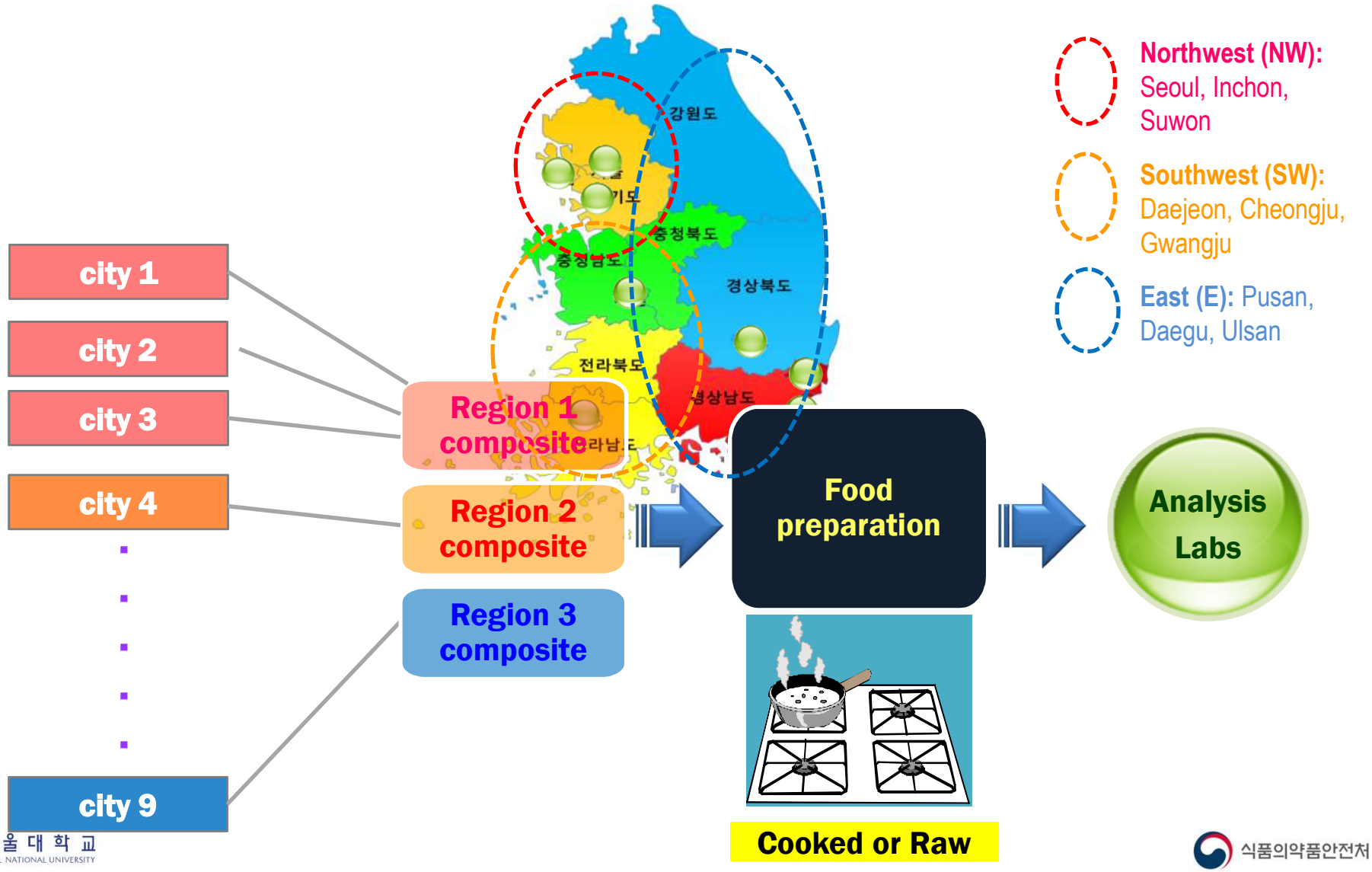
- Seoul & Kyeongki region, Cheolla & Choongchung region, and Kangwon & Kyeongsang region

▶ To secure 6 composites/year (30 samples in 5 years) for each food item, 2 different combinations of cities were used:

- Seasonality of the raw commodity foods considered (ex. spring to summer and summer to fall samples from 3 regions)
- Processed foods w/o seasonality: Combination of cities based on population size for 6 composites

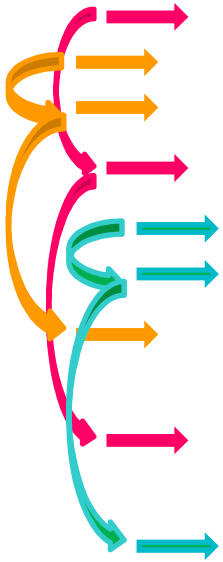
Sampling Sites for Representative Foods

< Sampling at 9 metropolitan cities ⇒ 6 composite Samples ⇒ preparation >



Composite of RFs by Sampling Sites and Seasonality

w/ seasonality



Administrative District	2016		
	Total population	Male	Female
Nationwide	51,269,554	25,696,987	25,572,567
SEOUL	9,805,506	4,799,115	5,006,391
Pusan	3,440,484	1,694,026	1,746,458
Daegu	2,461,002	1,223,733	1,237,269
Incheon	2,913,024	1,465,699	1,447,325
Kwangju	1,501,557	747,303	754,254
Daejeon	1,535,445	770,971	764,474
Ulsan	1,166,033	605,618	560,415
Sejong	242,507	122,648	119,859
Kyeongji-do	12,671,956	6,405,301	6,266,655
Kangwon-do	1,521,751	769,461	752,290
Choongchungbuk-do	1,603,404	814,049	789,355
Choongchungnam-do	2,132,566	1,091,091	1,041,475
Cheollabuk-do	1,833,168	915,493	917,675
Cheollanam-do	1,796,017	901,500	894,517
Kyeongsangbuk-do	2,682,169	1,354,997	1,327,172
Kyeongsangnam-do	3,339,633	1,701,849	1,637,784
Cheju-do	623,332	314,133	309,199

w/o seasonality

Seoul,
Incheon,
Suwon,
Pusan,
Daegu + Ulsan,

Kwangju + Daejeon + Cheong-ju

서 울 대 학 교
SEOUL NATIONAL UNIVERSITY

식품의약품안전처

Seasonality of raw commodity type foods

▶ Raw commodity type food samples

- Foods with 1 major season or processed foods: One collection/year
- Foods available at market throughout the year but with variable amount: Two collections/year ex) fresh Garlic vs stored garlic

Mar. 2017 ~ Feb. 2018: circulation amount in tons

Foods at market	2017										2018	
	3	4	5	6	7	8	9	10	11	12	1	2
Melon	2,126	4,134	7,525	9,011	5,448	1,580	780	162	1	6	26	432
Banana	5,506	5,628	6,822	6,123	5,555	4,657	5,483	4,973	5,126	4,473	4,839	4,009
Carrot	4,463	3,725	4,414	3,932	3,738	3,981	4,293	3,686	3,655	3,626	3,569	3,682
Lettuce	2,973	2,770	3,044	2,527	1,704	1,506	2,281	2,299	2,123	2,071	1,873	1,684
Crab	79	52	68	73	51	45	37	74	67	34	63	65
Radish	16,143	13,950	14,393	12,277	11,776	13,770	19,191	13,510	10,235	10,225	12,011	12,656
Tomato	5,296	7,533	9,001	8,457	6,431	3,895	4,049	4,545	3,475	3,839	3,687	3,854
Cucumber	9,418	13,026	18,753	17,325	8,303	6,760	7,427	5,702	4,952	4,946	4,591	5,060
Spinach	3,478	2,300	2,125	1,784	915	436	1,691	2,173	2,660	3,430	3,645	3,528
Garlic	3,142	3,358	5,954	4,657	2,533	2,437	2,870	2,286	3,565	603	2,733	2,639
Apples	3,838	3,005	2,926	2,225	1,873	3,317	8,372	3,446	4,131	3,327	4,292	4,835
Peppers	4,205	4,210	5,260	5,167	4,521	4,740	4,357	3,953	3,755	3,611	3,013	2,821
Onions	17,432	22,670	25,070	20,964	16,296	18,727	19,755	15,304	17,539	17,450	15,358	15,620
Mandarin oranges	2,009	513	243	310	367	385	782	6,217	11,346	14,382	12,221	8,161
potatoes	7,208	7,896	9,381	13,444	6,808	6,073	5,732	4,620	5,517	5,204	5,369	4,504
Persimmon	1	-	-	-	-	-	702	5,666	6,661	2,338	971	71

Seasonality of raw commodity type foods

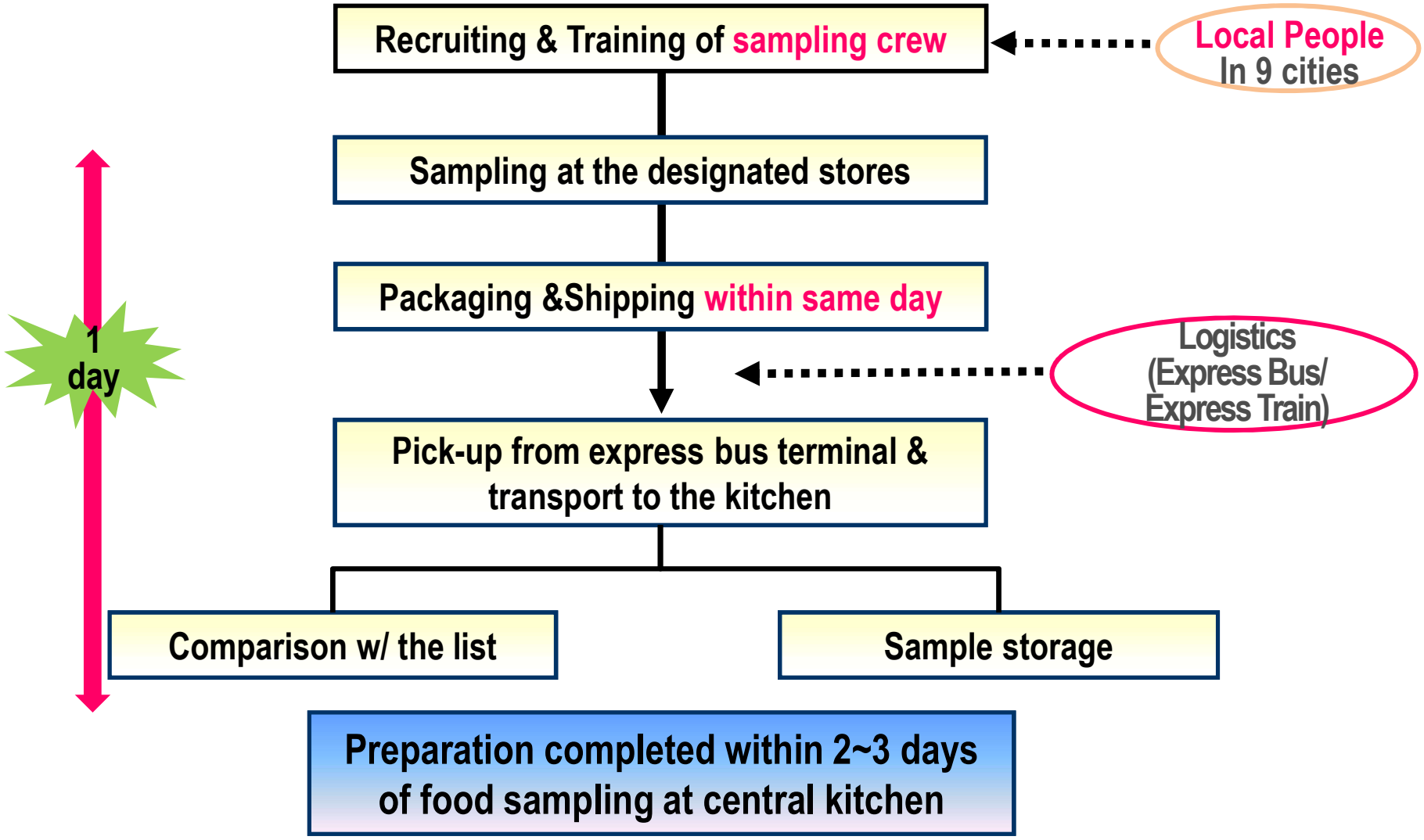
▶ Raw commodity type food samples

- Foods with 1 major season or processed foods: One collection/year
- Foods available at market throughout the year but with variable amount: Two collections/year ex) female vs male crabs

Feb. ~ Dec. 2021: circulation amount in tons

Foods at market	2021										
	2	3	4	5	6	7	8	9	10	11	12
Eggplant	798	1,129	1,737	2,004	2,332	2,852	2,370	2,347	1,621	1,140	877
Scallop	15	17	11	10	7	6	4	7	19	32	33
Mandarin oranges	8,055	3,385	856	298	372	412	510	1,088	5,922	8,667	11,621
Potato	4,946	6,966	8,501	11,166	11,296	5,203	5,114	4,818	5,478	5,125	5,810
Red pepper powder	119	137	152	115	128	133	129	151	169	174	186
Crab (female)	48	59	58	51	54	21	18	38	23	35	34
Sweet potato	3,937	4,817	3,689	2,994	2,786	2,844	4,084	4,465	4,474	3,672	5,003
Bracken fern	439	318	322	306	312	290	297	423	323	333	287
Mackerel	460	635	610	593	1,007	676	729	689	730	789	754
Oysters	278	97	28	12	8	5	7	22	115	539	544
Perilla leaves	949	1,200	1,165	1,204	1,393	1,251	1,169	1,035	1,080	982	913
Crab (male)	36	37	39	59	49	33	58	146	206	172	90
Kiwi	254	257	437	708	679	612	556	651	641	457	419
Small octopus	73	91	117	118	124	108	77	121	120	115	115
Carrot	4,164	4,486	4,075	4,164	4,277	3,583	4,193	4,415	3,883	3,890	4,164
Pollack	616	206	205	562	343	118	135	1,005	313	507	430
Strawberry	4,623	6,000	4,050	1,331	81	2	2	4	55	1,195	2,566
Littleneck clam	234	313	319	325	294	233	226	247	293	282	281
Garlic	2,237	3,246	3,516	4,098	4,165	2,701	3,143	3,544	2,231	3,022	2,418
Radish	13,840	15,439	13,467	13,249	12,350	11,277	13,275	17,283	14,689	10,118	10,651
Water dropwort	912	1,720	1,807	1,284	1,164	983	728	795	808	1,094	839

Collection of Representative Foods in Korean TDS



Sample preparation for chemical analysis

▶ Weighing utensils

Sample preparation for chemical analysis

▶ Preparation/cooking

끓이기(Boiling)

•방법
식품을 끓는 물과 함께 넣어 장시간 익히기
•예시
국,탕,조림 등

데치기(Blanching/parboiling)

•방법
끓는 물에 식품을 단시간 익힌 후 건지기
•예시
시금치 등 숙채 나물 등

삶기 (Boiling & draining)

•방법
끓는 물에 식품을 장시간 익힌 후 건지기
•예시
국수, 밤, 달걀 등

Sample preparation for chemical analysis

▶ Preparation/cooking

볶기(Stir-frying)

•방법
170℃로 예열된 팬에서 휘저어가며 익히기
•예시
나물 볶음, 볶음밥 등

부치기(Pan-frying)

•방법
170℃로 예열된 팬에서 뒤집으며 익히기
•예시
전, 생선구이, 호떡 등

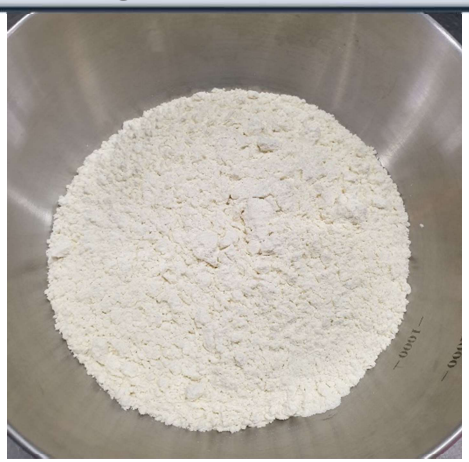
굽기(Grilling/roasting/baking/broiling)

•방법
180℃로 예열된 석쇠 또는 오븐에서 익히기(기름 사용 안 함)
•예시
숯불구이, 오븐구이, 빵 등

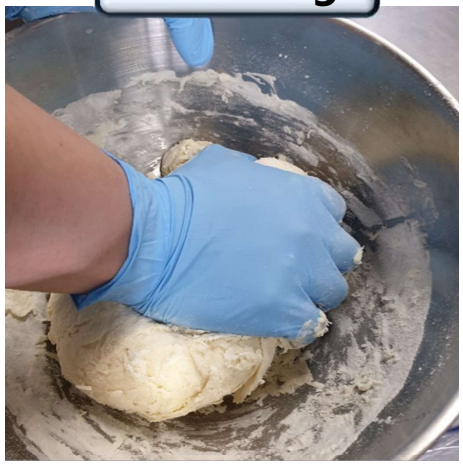
Sample preparation for chemical analysis

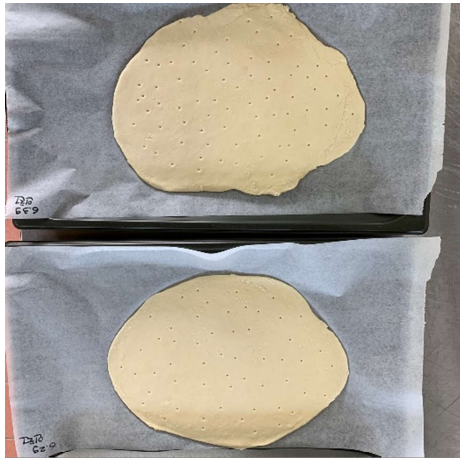
▶ Wheat flour: baking

Pooling into composite



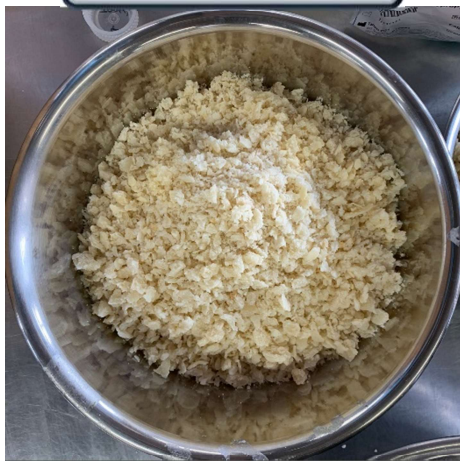
Kneading





Baking

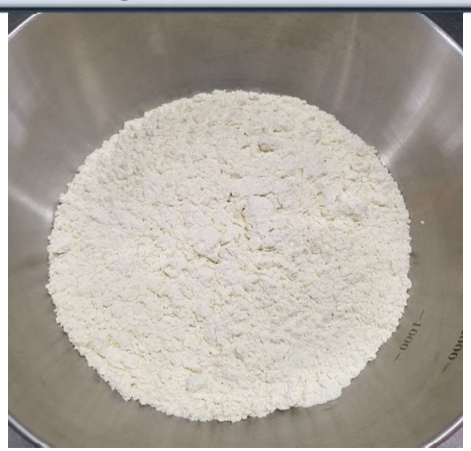
Pulverization



Sample preparation for chemical analysis

▶ Wheat flour: pan-frying

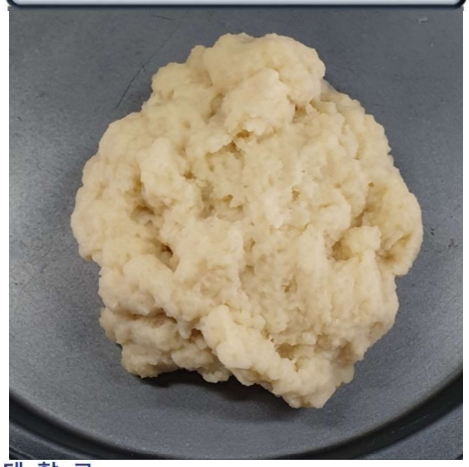
Pooling into composite



Mixing w/water

Pan-frying

Homogenization



Sample preparation for chemical analysis

▶ Mackerel: grilling

Cleaning & pre-prep

Pooling into composite

Grilling

Bone removal

Homogenization

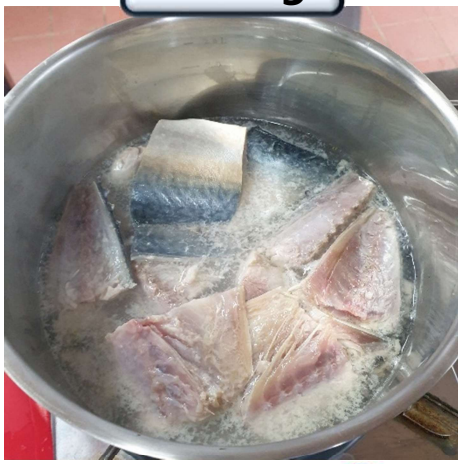
Sample preparation for chemical analysis

▶ Mackerel-boiling

Cleaning & pre-prep

Pooling into composite

Boiling



Bone removal

Homogenization

Making aliquots of the prepared samples for analysis

▶ **Make aliquots of necessary amount for each analysis**

Homogenization

Aliquotting

Packing & freezing

Stored sample aliquots as of July 2022

TDS Year	No. of cooked samples	No. of aliquots stored
2018	1,344	1,344
2019	1,362	1,362
2020	1,392	5,568
2020 Winter	111	444
2021	1,416	5,664

Analysis of Heavy Metals, Mycotoxins, and Nutrients

▶ Analytes

- Heavy metals:

- Lead (Pb), cadmium (Cd), arsenic (As), inorganic arsenic (I-As), aluminum (Al), mercury (Hg), methyl mercury (MeHg)

- Mycotoxins:

- Aflatoxin $B_1/B_2/G_1/G_2$, Ochratoxin A, Fumonisine B_1/B_2, Zeralenone

- Nutrients:

- Calcium, iron, zinc, vitamin D (D_2, D_3), Iodine, sodium, potassium, magnesium, etc.

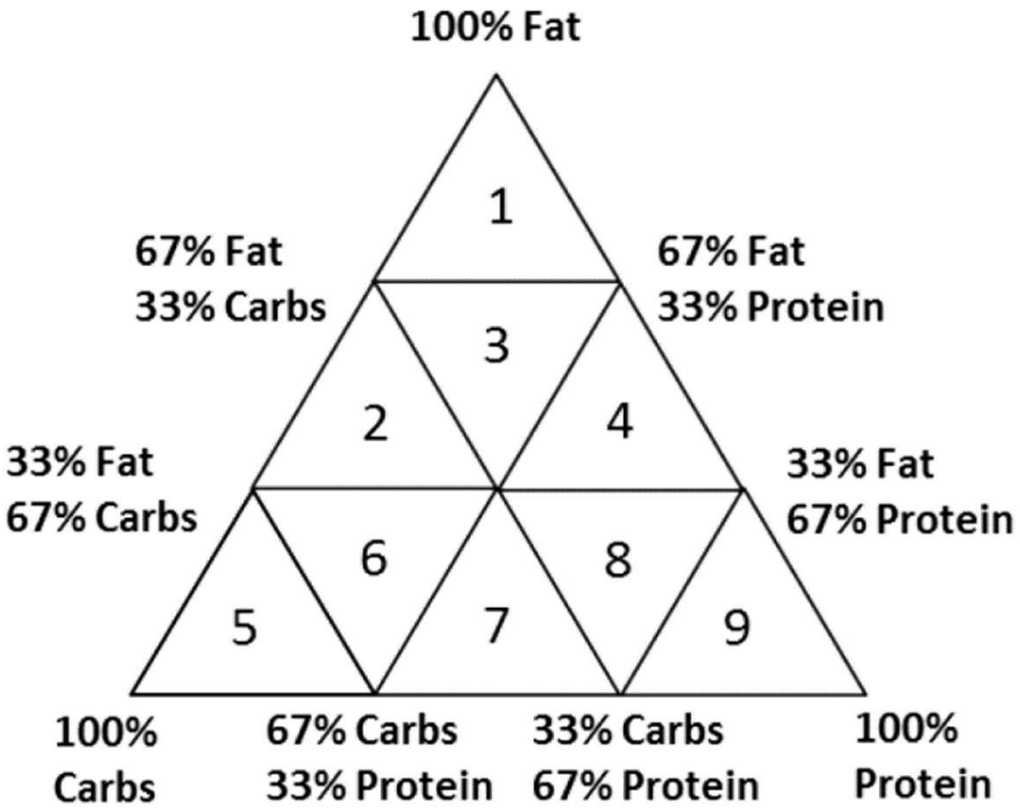
Analysis of Heavy Metals, Mycotoxins, and Nutrients: Representative Matrices

- Preparation of representative food matrices for cooked food sample analysis

 Rice porridge (low fat solid)	 Tomato juice (low fat liquid)	 Beef loin (high fat solid)	 Cod (high hat solid)	 Sunflower seed oil (high fat liquid)
Grains & cereals, tubers, beans, nuts, mushrooms, cookies, breads, noodles, rice cake, etc.	Beverages & drinks, fruits, liquid seasonings, kimchi, etc. with relatively high water content	Meats and their products, processed foods, etc. with relatively high fat content	Fishes, shellfishes, crustacea, etc. with relatively high fat content	Fats & oils, dairy products, etc. with relatively high fat content

Analysis of Heavy Metals, Mycotoxins, and Nutrients: Revision on Representative Matrices

Guidelines for the Validation of Chemical Methods for the FDA FVM Program, 2015



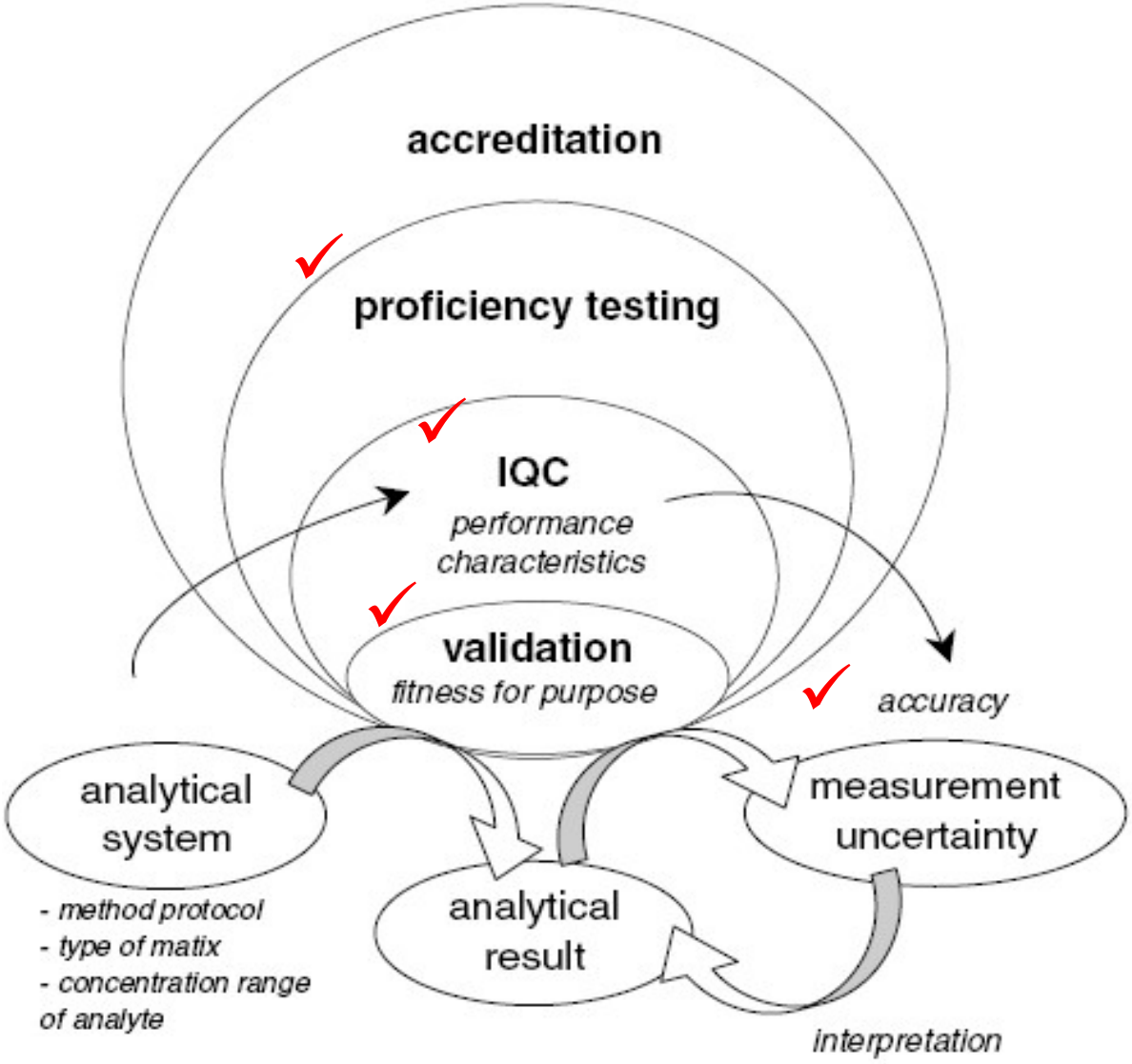
Analysis of Heavy Metals, Mycotoxins, and Nutrients: Revised Representative Matrices

- **Preparation methods given by matrix characteristics**
  - **1st : Fat content, liquid, solid**
  - **2nd : Applicability of preparation method (Confirmed with IS)**

					
Rice porridge (low fat solid)	Tomato juice (low fat liquid)	Peanut butter	Olive oil	Milk	Red pepper powder
Grains & cereals, tubers, beans, nuts, vegetables w/ water content≤80%, oysters, small octopus, etc.	Beverages & drinks, fruits, liquid seasonings, vegetables w/ water content > 80%, etc.	Cookies, Meats & their products, Mackerel, processed foods, etc. with relatively high fat content	Fats & oils, some dairy products, etc. with high fat content	Milk, ice cream, yogurt, liquid yogurt, etc.	(Spice & herbs) Red pepper powder, black pepper, coffee powder, fermented red pepper paste

Validation of analysis methods

※ Guide manual for QA & QC for Korean TDS



Results: Method Validation

Calibration

Matrix		AFB1	AFB2	AFG1	AFG2	OTA	FMB1	FMB2	ZEN	DON	AFM1
Rice porridge	Slope	1.0500	2.1400	1.0600	2.2100	2.0300	1.1000	1.0400	1.1300	1.1032	
	R^2	0.9982	0.9982	0.9962	0.9984	0.9946	0.9982	0.9978	0.9956	0.9893	-
	Range	0.03-0.9	0.05-0.9	0.07-1.5	0.06-1.5	0.2-3	1.2-75	2.8-75	0.7-60	10.0-200	
Tomato juice	Slope	1.057	1.947	1.179	1.450	1.855	0.964	0.873	1.084	0.975	
	R^2	0.9970	0.9986	0.9964	0.9964	0.9980	0.9928	0.9942	0.9978	0.9964	-
	Range	0.03-1.8	0.06-1.8	0.09-1.8	0.06-1.8	0.05-1.8	0.2-9	0.3-9	0.6-45	5.9-150	
Peanut butter	Slope	0.748	1.879	0.948	1.229	2.072	0.978	0.709	0.878	1.077	
	R^2	0.9989	0.9959	0.9965	0.9988	0.9954	0.9987	0.9966	0.9964	0.9957	-
	Range	0.05-2.1	0.05-2.1	0.10-2.1	0.50-9	0.50-30	3.0-45	3.0-45	1.0-60	10-200	
Red pepper powder	Slope	1.001	1.502	0.887	1.141	2.510	0.985	0.568	0.902	1.137	
	R^2	0.9979	0.9973	0.9979	0.9981	0.9984	0.9979	0.9973	0.9992	0.9998	-
	Range	0.02-0.3	0.03-0.3	0.02-0.3	0.09-0.9	0.15-3	0.5-12	0.7-6	0.26-8	3.42-100	
Olive oil	Slope	0.734	2.177	1.600	2.114	0.968	0.965	0.727	0.836	1.381	
	R^2	0.9988	0.9988	0.9990	0.9975	0.9991	0.9986	0.9959	0.9989	0.9960	-
	Range	0.06-0.9	0.08-0.9	0.18-2.4	0.19-2.4	0.03-1.5	0.6-18	0.6-18	0.24-6	1.2-30	
Milk	Slope	0.971	1.810	0.670	2.490	2.880	0.879	0.616	0.839	1.150	3.012
	R^2	0.9992	0.9968	0.9986	0.9972	0.9996	0.9980	0.9950	0.9994	0.9924	0.9980
	Range	0.009-0.3	0.006-0.3	0.013-0.3	0.009-0.3	0.03-1.5	0.6-15	0.2-15	0.1-15	0.1-25	0.018-0.3

Red: interference

Results: Method Validation

Limit of Detection (LOD)

Unit: μg/kg

Matrix	Year	AFB1	AFB2	AFG1	AFG2	OTA	FMB1	FMB2	ZEN	DON	AFM1
Rice porridge	2022	0.01	0.02	0.02	0.02	0.1	0.4	0.9	0.3	3.3	
	2021	0.01	0.02	0.02	0.02	0.1	0.4	0.9	0.3	3.3	
Peanut butter	2022	0.02	0.02	0.03	0.2	0.2	1.0	1.0	0.3	3.3	
	2021	0.01	0.02	0.03	0.2	0.2	1.0	1.0	0.3	3.6	
Tomato juice	2022	0.01	0.02	0.03	0.02	0.02	0.1	0.1	0.2	1.9	-
	2021	0.01	0.02	0.03	0.02	0.02	0.1	0.1	0.2	1.9	-
Red pepper powder	2022	0.008	0.009	0.005	0.03	0.05	0.18	0.23	0.09	1.13	-
	2021	0.008	0.009	0.01	0.02	0.07	0.4	0.2	0.13	1.29	
Olive oil	2022	0.02	0.03	0.06	0.06	0.01	0.2	0.2	0.08	0.4	-
	2021	0.02	0.03	0.06	0.06	0.01	0.5	0.4	0.08	0.4	-
Milk	2022	0.003	0.002	0.004	0.003	0.01	0.2	0.1	0.04	0.2	0.003
	2021	0.003	0.002	0.004	0.003	0.01	0.2	0.1	0.04	0.2	0.003

QA and QC

▶ QC Sample Analysis

- Red pepper powder

Fera Science Ltd (Fera)
Sand Hutton, York, YO41 1LZ
Tel: +44 (0)1904 462100 Fax: +44(0)1904 500440
info@fapas.com www.fapas.com

FAPAS QC MATERIAL DATA SHEET	T04286QC
Matrix	Chilli Powder
Weight / Volume of Contents	55g

Analyte	Assigned Value, X_a	Range for |z| ≤2	Units	No. of data points producing X_a
Aflatoxin B1	4.70	2.63 - 6.77	µg/kg	31
Aflatoxin B2	2.41	1.35 - 3.47	µg/kg	31
Aflatoxin G1	2.31	1.29 - 3.32	µg/kg	31
Aflatoxin G2	0.843	0.472 - 1.214	µg/kg	29
Aflatoxins (total)	10.3	5.8 - 14.9	µg/kg	29

- Coffee

Fera Science Ltd (Fera)
Sand Hutton, York, YO41 1LZ
Tel: +44 (0)1904 462100 Fax: +44(0)1904 500440
info@fapas.com www.fapas.com

FAPAS QC MATERIAL DATA SHEET	T17169QC
Matrix	Roasted Coffee
Weight / Volume of Contents	55g

Analyte	Assigned Value, X_a	Range for |z| ≤2	Units	No. of data points producing X_a
Ochratoxin A	5.01	2.81 - 7.21	µg/kg	42

QA and QC

FAPAS Proficiency Testing

2021 FAPAS Test result

Analyte	This study (ug/kg)	Assigned value (ug/kg)	Z-score
Aflatoxin B1	2.76	3.12	-0.5
Deoxynivalenol (DON)	775	959	-1.2
Zearalenone (ZEN)	104	122	-0.7
Ochratoxin A	3.76	3.79	0.0
FB1	358	330	0.5
FB2	442	414	0.4
Total Fumonisins (sum FB1 & FB2)	800	720	0.7

$-1.2 \leq Z \leq 0.7$: very well fit-for-purpose

Intake of Chemicals	Exposure to Chemicals
$I_{i,j} = \sum_{k=1}^{n} C_{i,k} \times L_{k,j}$	$B_{i,j} = \frac{\sum_{k=1}^{n} C_{i,k} \times L_{k,j}}{BW_i}$
$I_{i,j}$: Total intake of chemical (j) by individual (i) in μg/person/day	$E_{i,j}$: Total exposure to chemical (j) of individual (i) in μg/kg b.w./day
n: Number of foods ingested by individual (i)	n: Number of foods ingested by individual (i)
$C_{i,k}$: Intake amount of food (k) by individual (i) in g/day	$C_{i,k}$: Intake of food (k) by individual (i) in g/day
$L_{k,j}$: Concentration of chemical (j) in food (k) in μg/kg	$L_{k,j}$: Concentration of chemical (j) in food (k) in μg/kg
	BW_i: Bodyweight (kg) of individual (i)

Estimation of exposure to heavy metals: the 1st year

	ND[1)]	Mean and Distribution of exposure (㎍/kg b.w./day)								
		Mean	(SE)	5th	10th	25th	50th	75th	90th	95th
Pb	LB	0.0636	0.0008	0.0073	0.0106	0.0188	0.0348	0.0679	0.1410	0.2149
	MB	0.0849	0.0008	0.0191	0.0245	0.0366	0.0568	0.0949	0.1675	0.2411
	UB	0.1062	0.0009	0.0287	0.0363	0.0526	0.0781	0.1237	0.1977	0.2718
Cd	LB	0.2077	0.0044	0.0569	0.0746	0.1081	0.1586	0.2360	0.3452	0.4421
	MB	0.2190	0.0045	0.0642	0.0829	0.1170	0.1692	0.2489	0.3608	0.4616
	UB	0.2304	0.0045	0.0709	0.0898	0.1260	0.1802	0.2620	0.3777	0.4812
Al	LB	32.150	0.343	7.311	9.731	15.036	24.043	38.481	60.548	81.277
	MB	32.357	0.343	7.465	9.885	15.220	24.243	38.719	60.757	81.549
	UB	32.564	0.344	7.601	10.012	15.394	24.443	38.914	61.071	81.858
As	LB	2.508	0.038	0.235	0.363	0.683	1.437	3.033	5.523	7.857
	MB	2.520	0.038	0.245	0.372	0.694	1.450	3.046	5.541	7.879
	UB	2.531	0.038	0.255	0.382	0.707	1.461	3.059	5.551	7.889
I-As	LB	0.3389	0.0023	0.0486	0.0968	0.1766	0.2906	0.4399	0.6268	0.7827
	MB	0.3396	0.0023	0.0490	0.0974	0.1770	0.2912	0.4403	0.6272	0.7835
	UB	0.3403	0.0023	0.0494	0.0976	0.1775	0.2922	0.4412	0.6285	0.7847
Hg	LB	0.0153	0.0004	0.0000	0.0000	0.0003	0.0024	0.0154	0.0426	0.0681
	MB	0.0293	0.0004	0.0064	0.0082	0.0117	0.0181	0.0326	0.0597	0.0858
	UB	0.0434	0.0005	0.0123	0.0155	0.0218	0.0324	0.0507	0.0801	0.1079
Methyl -Hg	LB	0.0055	0.0003	0.0000	0.0000	0.0000	0.0000	0.0006	0.0161	0.0319
	MB	0.0055	0.0003	0.0000	0.0000	0.0000	0.0000	0.0006	0.0161	0.0319
	UB	0.0055	0.0003	0.0000	0.0000	0.0000	0.0000	0.0006	0.0161	0.0319

1) LB: lower bound, MB: middle bound, UB: upper bound

Contribution to heavy metal exposure by food item

rank	lead (㎍/kg b.w./day)				Cadmium (㎍/kg b.w./day)			
	food	Mean	Contribution (%)	Cumulative %	food	Mean	Contribution (%)	Cumulative %
1	Sweet potato	0.0099	15.5	15.5	Rice	0.0512	24.6	24.6
2	Perilla leaves	0.0096	15.0	30.5	Scallop	0.0138	6.6	31.2
3	Turnip greens	0.0084	13.2	43.6	Laver	0.0136	6.5	37.7
4	Surf clam	0.0029	4.6	48.2	Squid	0.0120	5.8	43.4
5	Rice cake	0.0026	4.0	52.2	Kimchi, Nappa	0.0088	4.2	47.7
6	breads	0.0021	3.3	55.5	Crab	0.0073	3.5	51.2
7	Kimchi, Nappa	0.0019	3.0	58.5	Wakame	0.0071	3.4	54.6
8	Coffee	0.0016	2.6	61.0	Sweet rice	0.0063	3.0	57.5
9	Wakame	0.0016	2.5	63.6	Breads	0.0042	2.0	59.6
10	Laver	0.0015	2.3	65.9	Ramen	0.0040	1.9	61.5

rank	Aluminum (㎍/kg b.w./day)			
	food	Mean	Contribution (%)	Cumulative %
1	Surf clam	2.692	8.4	8.4
2	Pork	2.483	7.7	16.1
3	Anchovies	1.654	5.1	21.2
4	Rice	1.487	4.6	25.8
5	Mussels	1.390	4.3	30.1
6	Green tea	1.219	3.8	33.9
7	Turnip greens	1.207	3.7	37.6
8	Laver	1.141	3.5	41.2
9	Shrimp	0.800	2.5	43.7
10	Red pepper paste	0.730	2.3	45.9

Contribution to heavy metal exposure by food item

Rank	Arsenic (㎍/kg b.w./day)				Inorganic arsenic (㎍/kg b.w./day)			
	food	Mean	Contribution (%)	Cumulative %	food	Mean	Contribution (%)	Cumulative %
1	Laver	0.5425	21.6	21.6	Rice	0.2934	86.4	86.4
2	Rice	0.4029	16.0	37.6	Brown rice	0.0224	6.6	92.9
3	Wakame	0.2865	11.4	49.0	Sweet rice	0.0145	4.3	97.2
4	Anchovies	0.1728	6.9	55.9	Rice cake	0.0094	2.8	100.0
5	Crab	0.1629	6.5	62.4				
6	Pollack	0.1454	5.8	68.1				
7	Squid	0.1378	5.5	73.6				
8	Mackerel	0.1233	4.9	78.5				
9	Surf clam	0.1012	4.0	82.6				
10	Octopus	0.0998	4.0	86.5				

Rank	Mercury (㎍/kg b.w./day)				Methyl mercury (㎍/kg b.w./day)			
	food	Mean	Contribution (%)	Cumulative %	food	Mean	Contribution (%)	Cumulative %
1	Squid	0.0037	24.2	24.2	Mackerel	0.0020	36.4	36.4
2	Mackerel	0.0026	17.3	41.5	Tuna	0.0018	32.1	68.5
3	Tuna	0.0025	16.4	57.9	Pollack	0.0016	29.1	97.6
4	Pollack	0.0024	15.7	73.6	Anchovies	0.0001	2.4	100.0
5	Fish paste cake	0.0008	5.6	79.1				
6	Crab	0.0006	4.2	83.3				
7	Shrimp	0.0006	3.7	87.0				
8	Octopus	0.0006	3.6	90.7				
9	Brown rice	0.0004	2.5	93.2				
10	Surf clam	0.0004	2.4	95.6				

Estimation of exposure to mycotoxins: the 1st year

	ND[1)]	Mean and Distribution of exposure (ng/kg b.w./day)								
		Mean	(SE)	5th	10th	25th	50th	75th	90th	95th
Aflatoxin B_1	LB	0.1454	0.0053	0.0000	0.0002	0.0039	0.0172	0.0594	0.2914	0.7131
	MB	0.3657	0.0055	0.0927	0.1162	0.1619	0.2303	0.3527	0.6324	1.0430
	UB	0.5861	0.0060	0.1791	0.2236	0.3102	0.4339	0.6410	1.0205	1.4342
Aflatoxin B_2	LB	0.0355	0.0007	0.0000	0.0001	0.0015	0.0131	0.0427	0.0880	0.1310
	MB	0.3365	0.0017	0.1175	0.1482	0.2082	0.2955	0.4105	0.5647	0.6925
	UB	0.6374	0.0032	0.2267	0.2851	0.3998	0.5641	0.7805	1.0635	1.2912
Aflatoxin G_1	LB	0.0050	0.0001	0.0000	0.0000	0.0001	0.0012	0.0057	0.0131	0.0209
	MB	0.4369	0.0021	0.1578	0.1982	0.2761	0.3878	0.5355	0.7275	0.8804
	UB	0.8688	0.0042	0.3127	0.3930	0.5477	0.7710	1.0650	1.4471	1.7511
Aflatoxin G_2	LB	0.0357	0.0013	0.0000	0.0000	0.0000	0.0077	0.0353	0.0939	0.1501
	MB	0.7672	0.0051	0.2169	0.2827	0.4241	0.6427	0.9612	1.3749	1.7327
	UB	1.4987	0.0097	0.4283	0.5549	0.8305	1.2583	1.8690	2.6904	3.3807
Fumonosin B_1	LB	1.223	0.018	0.000	0.007	0.123	0.470	1.386	3.209	5.017
	MB	17.087	0.086	6.083	7.545	10.480	14.643	20.617	29.488	36.594
	UB	32.952	0.163	11.873	14.646	20.392	28.370	39.869	56.538	70.110
Fumonisin B_2	LB	0.278	0.007	0.000	0.000	0.007	0.038	0.221	0.666	1.329
	MB	16.915	0.085	6.015	7.462	10.414	14.523	20.550	29.120	36.183
	UB	33.552	0.169	11.902	14.761	20.634	28.781	40.747	57.873	71.899
Ochratoxin A	LB	0.2041	0.0039	0.0071	0.0179	0.0507	0.1127	0.2136	0.3718	0.5715
	MB	1.4065	0.0079	0.4851	0.5981	0.8363	1.1795	1.7014	2.4894	3.1351
	UB	2.6089	0.0137	0.9212	1.1318	1.5787	2.2157	3.1782	4.5777	5.6099
Zearalenon	LB	2.3610	0.0340	0.0322	0.0994	0.3298	1.0801	2.8786	5.9764	8.7684
	MB	7.6693	0.0456	2.4450	3.1196	4.4682	6.4861	9.3936	13.3255	16.7869
	UB	12.9777	0.0664	4.5317	5.7207	8.0848	11.3994	15.9366	21.7627	26.4871

1) LB: lower bound, MB: middle bound, UB: upper bound

Estimated Nutrient Intake: Iron, Zinc, Calcium & Vitamin D_3

	ND[1)]	Mean and Distribution of Nutrient Intake per person per day of Koreans								
		Mean	(SE)	5th	10th	25th	50th	75th	90th	95th
Iron (mg/capita/day)	LB	7.61	0.04	2.30	3.03	4.52	6.64	9.56	13.11	15.79
	MB	7.62	0.04	2.30	3.03	4.52	6.64	9.57	13.11	15.81
	UB	7.62	0.04	2.30	3.03	4.52	6.65	9.58	13.12	15.83
Zinc (mg/capita/day)	LB	9.97	0.05	3.53	4.48	6.29	8.79	12.19	16.59	20.03
	MB	9.98	0.05	3.54	4.48	6.29	8.80	12.20	16.60	20.04
	UB	9.99	0.05	3.54	4.48	6.29	8.80	12.21	16.61	20.06
Calcium (mg/capita/day)	LB	457.38	2.86	124.37	163.20	250.80	391.41	588.59	830.74	1006.02
	MB	457.38	2.86	124.37	163.20	250.80	391.41	588.59	830.74	1006.02
	UB	457.38	2.86	124.37	163.20	250.80	391.41	588.59	830.74	1006.02
Vitamin D_3 (μg/capita/day)	LB	0.292	0.006	0.000	0.000	0.000	0.092	0.301	0.609	1.034
	MB	0.366	0.006	0.000	0.000	0.019	0.194	0.408	0.727	1.159
	UB	0.483	0.007	0.000	0.000	0.026	0.249	0.584	1.063	1.612

1) LB: lower bound, MB: middle bound, UB: upper bound

Risk Assessment: Heavy Metals_2nd year

	Korean TDS 2019 (ug/kg bw/day)				Korean TDS 2018 (ug/kg bw/day)		2016 Risk Assessment Report (ng/kg bw/day)		Reference values	
	Mean	95th	RA, %		Mean	95th	Mean	95th	Reference	Type
Lead	0.049	0.146	12.9 (MOE)	4.3 (MOE)	0.064	0.215	0.209	0.814	0.63 μg/kg b.w./day	$BMDL_{10}$, Nephrotoxic
Cadmium	0.244	0.592	29.6	73.1	0.208	0.442	0.291	1.008	25 μg/kg b.w./month	PTMI
Arsenic	3.027	9.705	6.1	19.4	2.508	7.857	3.647	9.625	50 μg/kg b.w./day	TDI
Mercury	0.015	0.058	2.8	10.9	0.015	0.068	0.083	0.277	3.7 μg/kg b.w./week	TWI
Aluminum	30.076	75.781	10.0	25.3	32.150	81.277			0.3 mg/kg bw/day	TDI

Risk Assessment: Mycotoxins_2nd year

	Korean TDS 2019 (ng/kg bw/day)				Korean TDS 2018 (ng/kg bw/day)		2016 Risk Assessment Report (ng/kg bw/day)		Reference values	
	Mean	95th	RA, %		Mean	95th	Mean	95th	Reference	Type
Aflatoxin (B1+B2+G1+G2)	0.043	0.168	3,991 (MOE)	1,013 (MOE)	0.0398	0.1287	0.263	0.777	0.17 μg/kg b.w./day	$BMDL_{10}$
Aflatoxin B1	0.022	0.078	7,763 (MOE)	2,185 (MOE)	0.0398	0.1287			0.17 μg/kg b.w./day	$BMDL_{10}$
Fumonisin (B1+B2)	0.850	2.999	0.05	0.18	0.405	1.8724	49	196	1.65 μg/kg b.w./day	TDI
Ochratoxin A	0.148	0.472	0.9	3.0	0.0699	0.2537	1.882	4.051	0.11 μg/kg b.w./week	TWI
Zearalenon	2.482	8.899	0.6	2.2	1.6702	6.4022	4.356	13.475	0.4 μg/kg bw/day	TDI

LB: ND=0

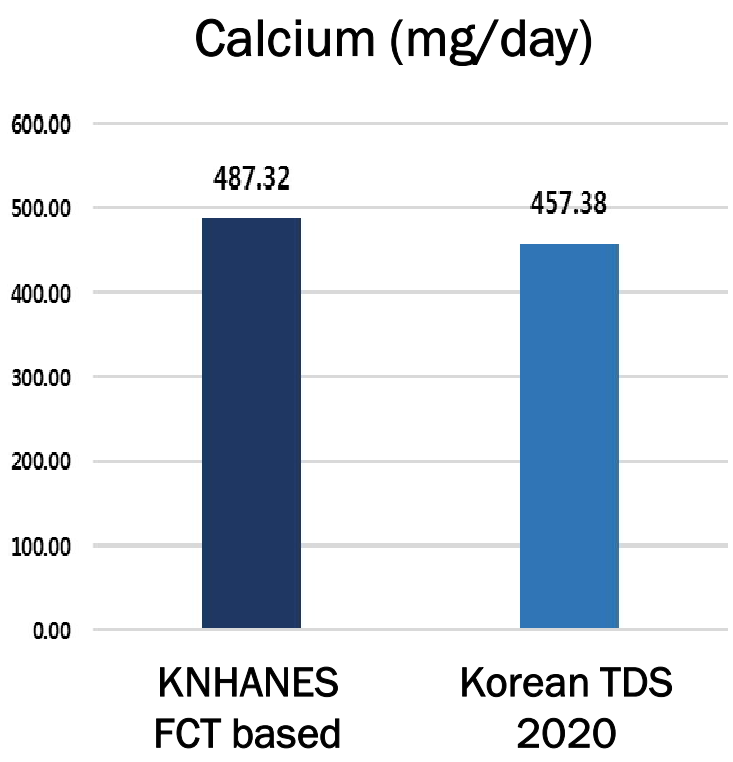
Risk Assessment: 2 ways of ND handling _2nd year

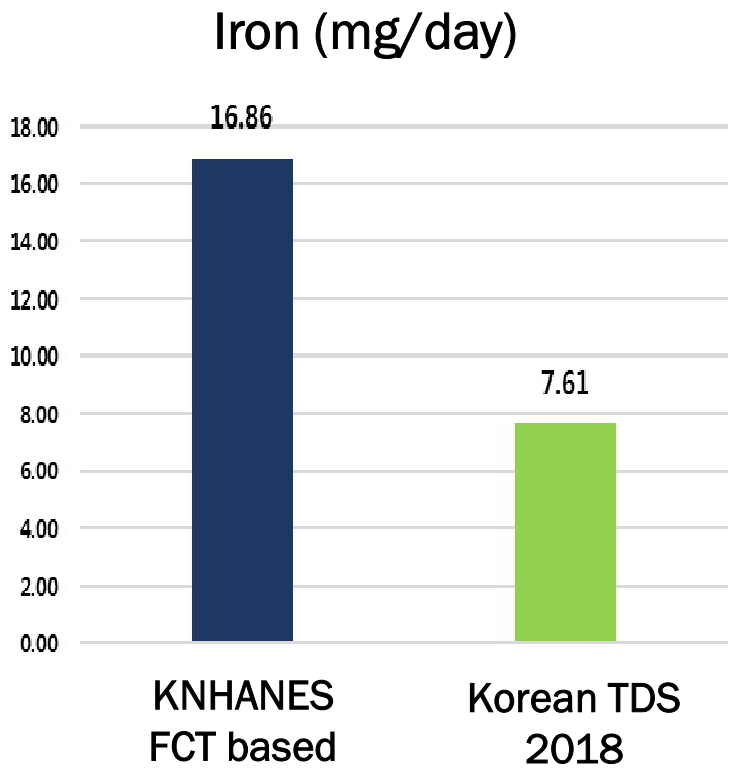
	Present approach (ng/kg bw/day)			Hybrid-approach (ng/kg bw/day)	
	LB	MB	UB	MB	UB
Mycotoxin					
Aflatoxin B1	0.0219	0.2403	0.4587	0.1147	0.2075
RA (MOE)	7,763	707	371	1,482	819

LB: ND=0, MB: ND=1/2 LOD, UB: ND=LOD

Nutrient Intake Estimation

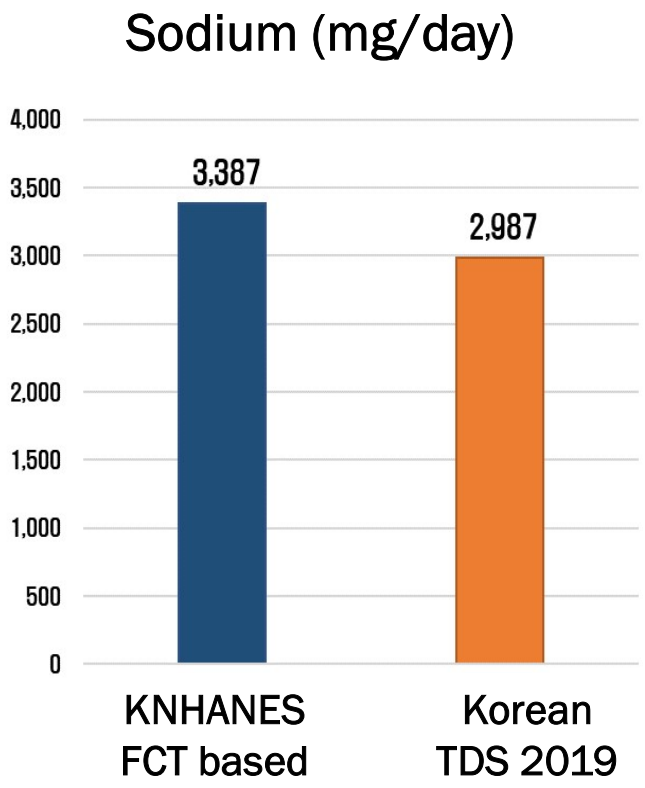
Comparison with Food Composition Table based estimation

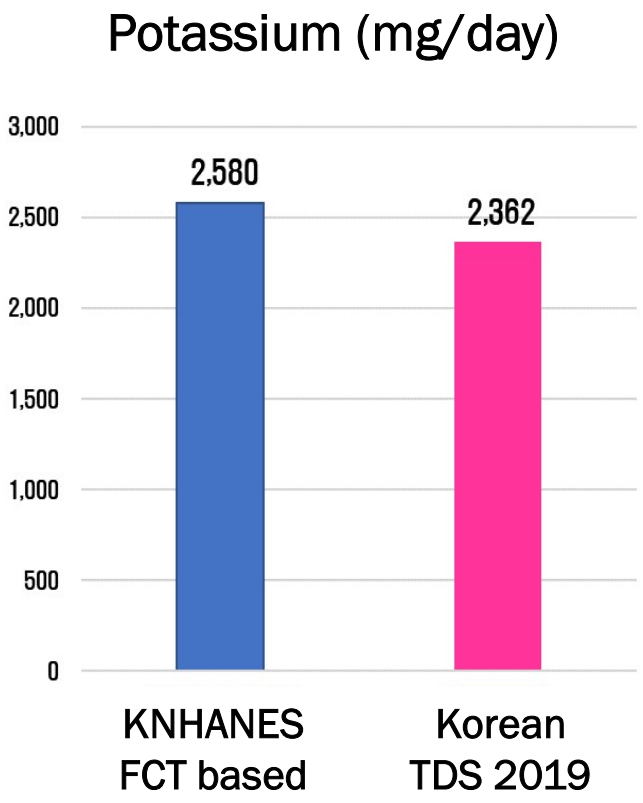




Nutrient Intake Estimation

Comparison with Food Composition Table based estimation





Estimated exposure to HMs & nutrient intake w/ & w/o mapping

	w/o Mapping		w/ Mapping		Increase (fold)
	Mean	95th	Mean	95th	
Heavy Metals (㎍/kg b.w./day)					
Pb	0.064	0.215	0.084	0.282	1.31
Cd	0.208	0.442	0.243	0.513	1.17
Al	32.150	81.277	43.582	114.584	1.36
As	2.508	7.857	3.720	11.969	1.48
Hg	0.015	0.068	0.030	0.130	1.94
Mycotoxins (ng/kg b.w./day)					
Aflatoxin B_1	0.145	0.713	0.152	0.724	1.05
Aflatoxin B_2	0.036	0.131	0.039	0.139	1.10
Aflatoxin G_1	0.005	0.021	0.006	0.023	1.17
Aflatoxin G_2	0.036	0.150	0.047	0.252	1.31
Fumonisin B_1	1.223	5.017	1.328	5.297	1.09
Fumonisin B_2	0.278	1.329	0.291	1.369	1.05
Ochratoxin A	0.204	0.572	0.228	0.668	1.12
Zearalenone	2.361	8.768	2.849	10.228	1.21
Nutrient Intake (mg/day)					
Iron	7.61	15.79	9.11	19.22	1.20
Zinc	9.97	20.03	10.92	21.61	1.10
Calcium	457.38	1006.02	540.71	1152.71	1.18
Vitamin D_3 (㎍/day)	0.29	1.03	0.36	1.41	1.24

RESULTS

▶ Number of NDs for each heavy metal by food group: 2018-2021 TDS

	Food group	No. of RFs (RF x prep. Method)	No. of samples	Number of NDs (% for each group)				
				Pb	Cd	Al	As	Hg
1	Grains & cereals	19 (24)	576	358(62.2)	27(4.7)	10(1.7)	109(18.9)	496(86.1)
2	Tubers	3 (6)	144	61(42.4)	48(33.3)	0(0.0)	33(22.9)	131(91.0)
3	Sugars & sweets	2 (5)	120	83(69.2)	117(97.5)	11(9.2)	69(57.5)	120(100.0)
4	Beans & pulses	3 (4)	93	49(52.7)	2(2.2)	0(0.0)	52(55.9)	93(100.0)
5	Nuts & seeds	2 (3)	72	45(62.5)	0(0.0)	0(0.0)	35(48.6)	65(90.3)
6	Vegetables	30 (52)	1236	682(55.2)	290(23.5)	38(3.1)	503(40.7)	1111(89.9)
7	Mushrooms	3 (7)	168	115(68.5)	9(5.4)	17(10.1)	48(28.6)	113(67.3)
8	Fruits	12 (12)	282	246(87.2)	233(82.6)	81(28.7)	201(71.3)	267(94.7)
9	Meats & poultry	8 (22)	528	459(86.9)	459(86.9)	42(8.0)	161(30.5)	467(88.4)
10	Eggs	1 (3)	72	61(84.7)	72(100.0)	4(5.6)	58(80.6)	53(73.6)
11	Fishes & shellfishes	13 (31)	744	146(19.6)	21(2.8)	8(1.1)	5(0.7)	25(3.4)
12	Seaweeds	2 (4)	96	0(0.0)	0(0.0)	0(0.0)	0(0.0)	30(31.3)
13	Milk & dairy products	6 (7)	168	132(78.6)	148(88.1)	3(1.8)	114(67.9)	151(89.9)
14	Fats & oils	4 (7)	168	150(89.3)	168(100.0)	21(12.5)	82(48.8)	123(73.2)
15	Beverage & alcohols	14 (14)	336	268(79.8)	291(86.6)	33(9.8)	246(73.2)	318(94.6)
16	Seasonings	11 (23)	546	323(59.2)	215(39.4)	55(10.1)	185(33.9)	463(84.8)
17	Prepared foods	2 (4)	96	45(46.9)	1(1.0)	0(0.0)	10(10.4)	86(89.6)
	Total	**135+α (228 +α)**	**5445+α**	**3223(59.2)**	**2101(38.6)**	**323(5.9)**	**1911(35.1)**	**4112(75.5)**

RESULTS

▶ Number of detection for each mycotoxin by food group: 2018-2021 TDS

	Food group	No. of samples	Number of Detects (detection rate % for each group)							
			AFB1	AFB2	AFG1	AFG2	FMB1	FMB2	OTA	ZEN
1	Grains & cereals	576	**30**	**4**	**2**	**1**	**46**	**18**	**28**	**126**
2	Tubers	144	0	0	0	0	0	0	0	**3**
3	Sugars & sweets	120	0	0	0	0	0	0	0	**3**
4	Beans & pulses	93	0	0	0	0	**1**	0	**4**	**21**
5	Nuts & seeds	72	**4**	0	0	**1**	0	0	**3**	**7**
6	Vegetables	1236	0	0	0	0	**17**	0	**10**	**1**
7	Mushrooms	168	0	0	0	0	0	0	0	0
8	Fruits	282	0	0	0	0	**6**	**1**	**1**	0
9	Meats & poultry	528	**1**	0	0	0	**31**	0	**1**	**8**
10	Eggs	72	0	0	0	0	0	0	0	0
11	Fishes & shellfishes	744	0	0	0	0	0	0	0	1
12	Seaweeds	96	0	0	0	0	0	0	**2**	12
13	Milk & dairy products	168	**1**	0	0	0	**1**	0	**4**	19
14	Fats & oils	168	**12**	0	0	0	0	0	**46**	134
15	Beverage & alcohols	336	**4**	0	0	0	**3**	0	**7**	14
16	Seasonings	546	**105**	**25**	**19**	0	**75**	**42**	**172**	139
17	Prepared foods	96	**8**	0	0	0	0	0	**9**	4
	Total	**5445+α**	**165(3.0)**	**29(0.5)**	**21(0.4)**	**2(0.04)**	**180(3.3)**	**61(1.1)**	**287(5.3)**	**492(9.0)**

RESULTS

▶ Estimated exposure of Koreans to heavy metals: TDS year & 5 year KTDS

	KTDS Tentative* (ug/kg bw/day)		2022 TDS (ug/kg bw/day)		2021 TDS (ug/kg bw/day)		2020 TDS (ug/kg bw/day)		2019 TDS (ug/kg bw/day)		2018 TDS (ug/kg bw/day)		2016 Risk assessment report (ug/kg bw/day)	
	Mean	95th	Mean	95th	Mean	95th	Mean	95th	Mean	95th	Mean	95th	Mean	95th
Heavy metals														
Pb	0.051	0.158	0.054	0.172	0.050	0.160	0.049	0.150	0.045	0.134	0.060	0.200	0.209	0.814
Cd	0.222	0.546	0.208	0.523	0.242	0.605	0.229	0.594	0.223	0.571	0.206	0.476	0.291	1.008
As	2.648	9.297	2.437	8.703	2.833	10.200	2.655	9.701	2.777	9.444	2.536	8.703	3.647	9.625
Hg	0.015	0.060	0.013	0.057	0.015	0.061	0.022	0.072	0.013	0.053	0.012	0.059	0.083	0.277
Al	28.742	77.975	33.554	92.660	29.351	89.161	23.062	64.024	28.471	71.682	29.235	77.139	-	-

* Based on 30 values for each 'RF x prep method' from 5 years (2016-2020 KNHANES food intake data) with ND=0.

RESULTS

▶ Estimated exposure of Koreans to mycotoxins: TDS year & 5 year KTDS

	K TDS Tentative* (ug/kg bw/day)		2022 TDS (ug/kg bw/day)		2021 TDS (ug/kg bw/day)		2020 TDS (ug/kg bw/day)		2019 TDS (ug/kg bw/day)		2018 TDS (ug/kg bw/day)		2016 Risk assessment report (ug/kg bw/day)	
	Mean	95th	Mean	95th	Mean	95th	Mean	95th	Mean	95th	Mean	95th	Mean	95th
Mycotoxins														
AF (B1+B2+ G1+G2)	0.031	0.119	0.018	0.043	0.020	0.116	0.044	0.159	0.039	0.145	0.036	0.121	0.263	0.777
AFB1	0.026	0.093	0.018	0.043	0.017	0.100	0.040	0.146	0.021	0.074	0.036	0.121	-	-
FMN (B1+B2)	0.910	3.447	0.331	1.750	1.527	7.456	1.549	6.884	0.734	2.533	0.404	1.720	49	196
OTA	0.170	0.501	0.180	0.678	0.252	0.795	0.211	0.626	0.139	0.450	0.068	0.251	1.882	4.051
ZEN	1.241	3.864	0.775	2.480	0.861	2.655	1.127	3.677	2.218	8.103	1.224	4.878	4.356	13.475

* Based on 30 values for each 'RF x prep method' from 5 years (2016-2020 KNHANES food intake data) with ND=0.

RESULTS

▶ Risk assessment (KTDS): exposure to mycotoxins

	Current method[1] (ng/kg bw/day)						US FDA Hybrid-approach[2] (ng/kg bw/day)				Reference value
	LB		MB		UB		MB		UB		
	Mean	95th	Mean	95th	Mean	95th	평균	95th	평균	95th	
AF (B1+B2 +G1+G2)	0.031	0.119	1.575	3.231	3.118	6.381	0.474	1.063	0.917	2.055	0.17 μg/kg b.w./day (BMDL$_{10}$)
MOE	5,484	1,429	108	53	55	27	359	160	185	83	
AFB1	0.026	0.093	0.202	0.408	0.377	0.752	0.090	0.205	0.153	0.338	0.17 μg/kg b.w./day (BMDL$_{10}$)
MOE	6,538	1,828	842	417	451	226	1,889	829	1,111	503	
FMN (B1+B2)	0.910	3.447	20.334	40.615	39.759	79.377	7.836	18.044	14.763	34.482	1.65 μg/kg b.w./day (TDI)
% TDI	0.06	0.21	1.23	2.46	2.41	4.81	0.47	1.09	0.89	2.09	
OTA	0.170	0.501	1.365	2.745	2.560	5.162	0.611	1.279	1.053	2.179	0.11 μg/kg b.w./wk (TWI)
% TWI	1.08	3.19	8.69	17.47	16.29	32.85	3.89	8.14	6.70	13.87	
ZEN	1.241	3.864	5.143	10.481	9.046	17.975	2.347	5.598	3.453	7.703	0.4 μg/kg b.w./day (TDI)
% TDI	0.31	0.97	1.29	2.62	2.26	4.49	0.59	1.40	0.86	1.93	

1) LB = Lower Bound (ND=0), MB = Middle Bound (ND=1/2 LOD), UB = Upper Bound (ND=LOD)

2) LB (ND=0 for NDs with no prior detection), MB (ND=1/2 LOD) or UB (ND=LOD) for NDs with prior detection

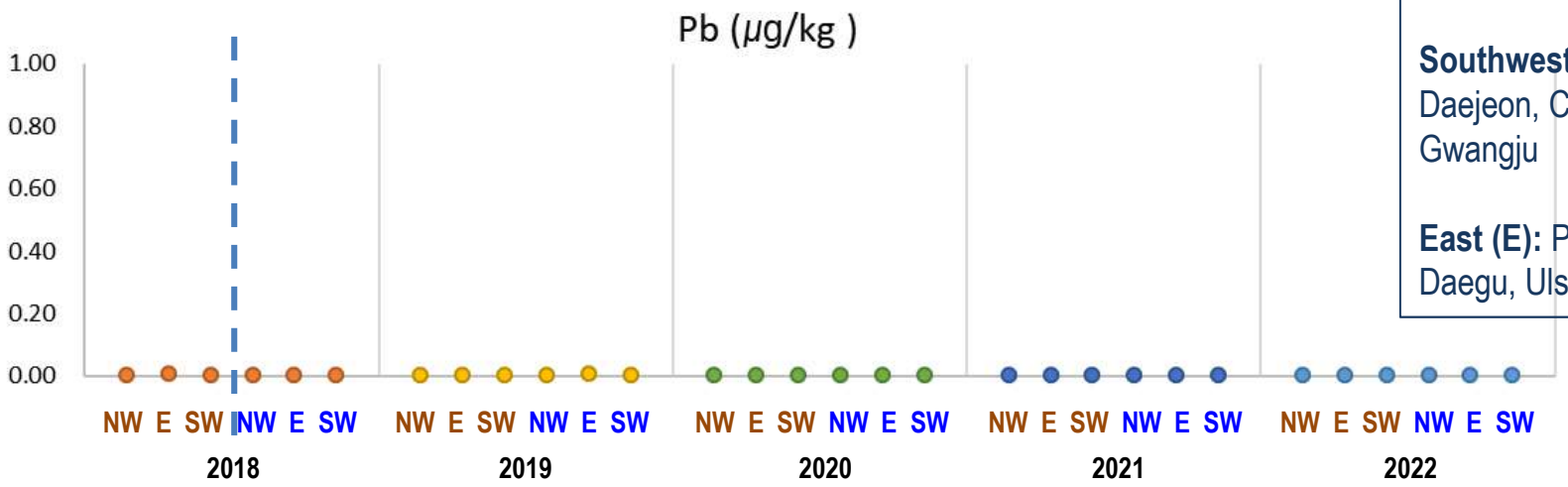
RESULTS

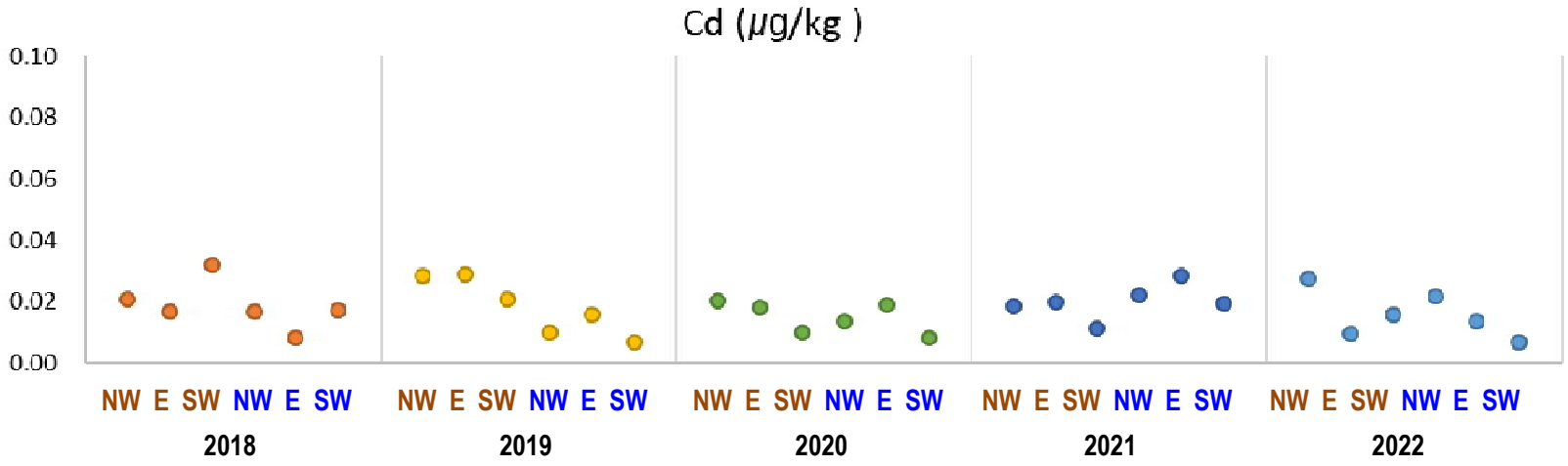
▶ Heavy metal content in rice by sampling site and season

Northwest (NW): Seoul, Inchon, Suwon

Southwest (SW): Daejeon, Cheongju, Gwangju

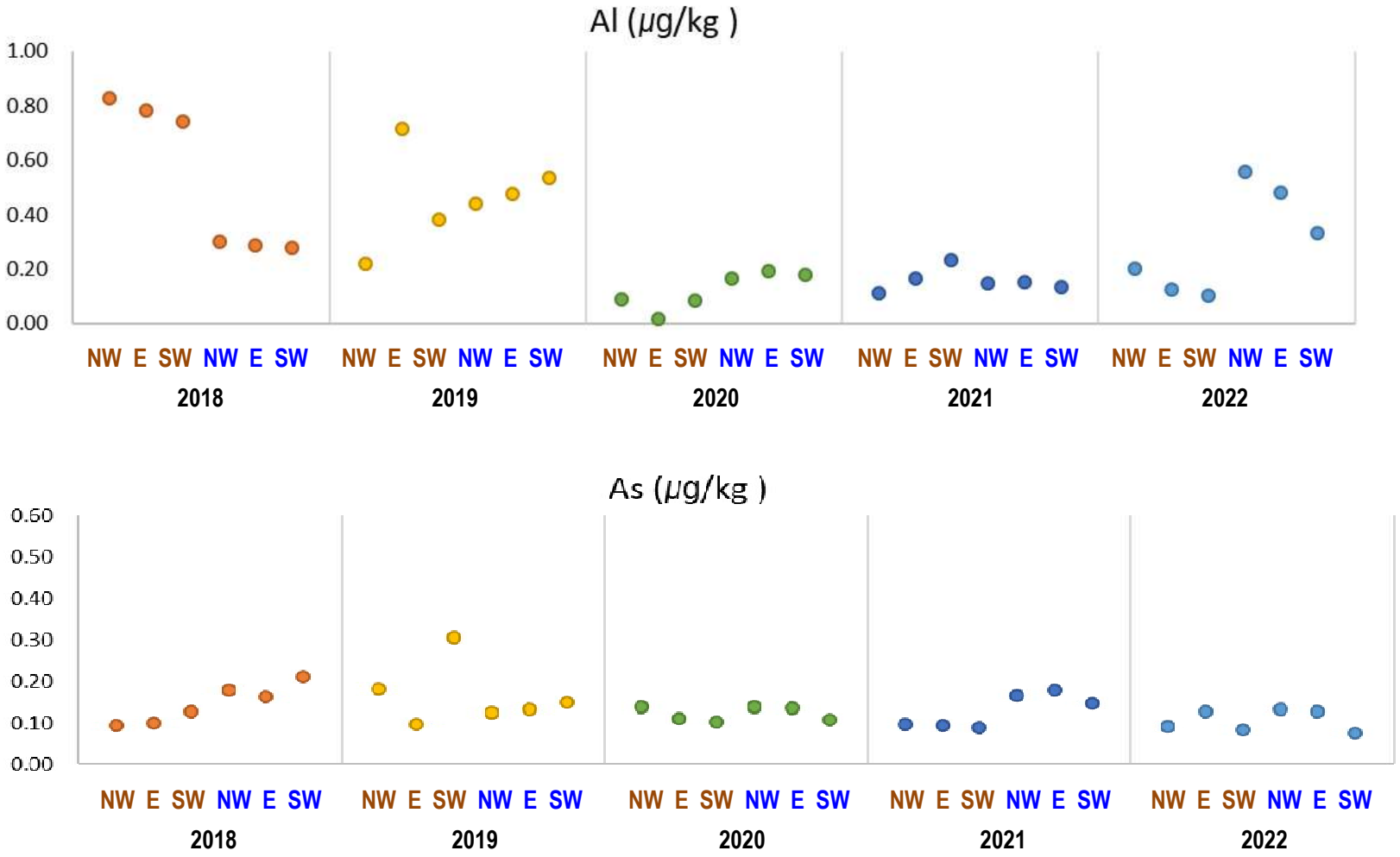
East (E): Pusan, Daegu, Ulsan





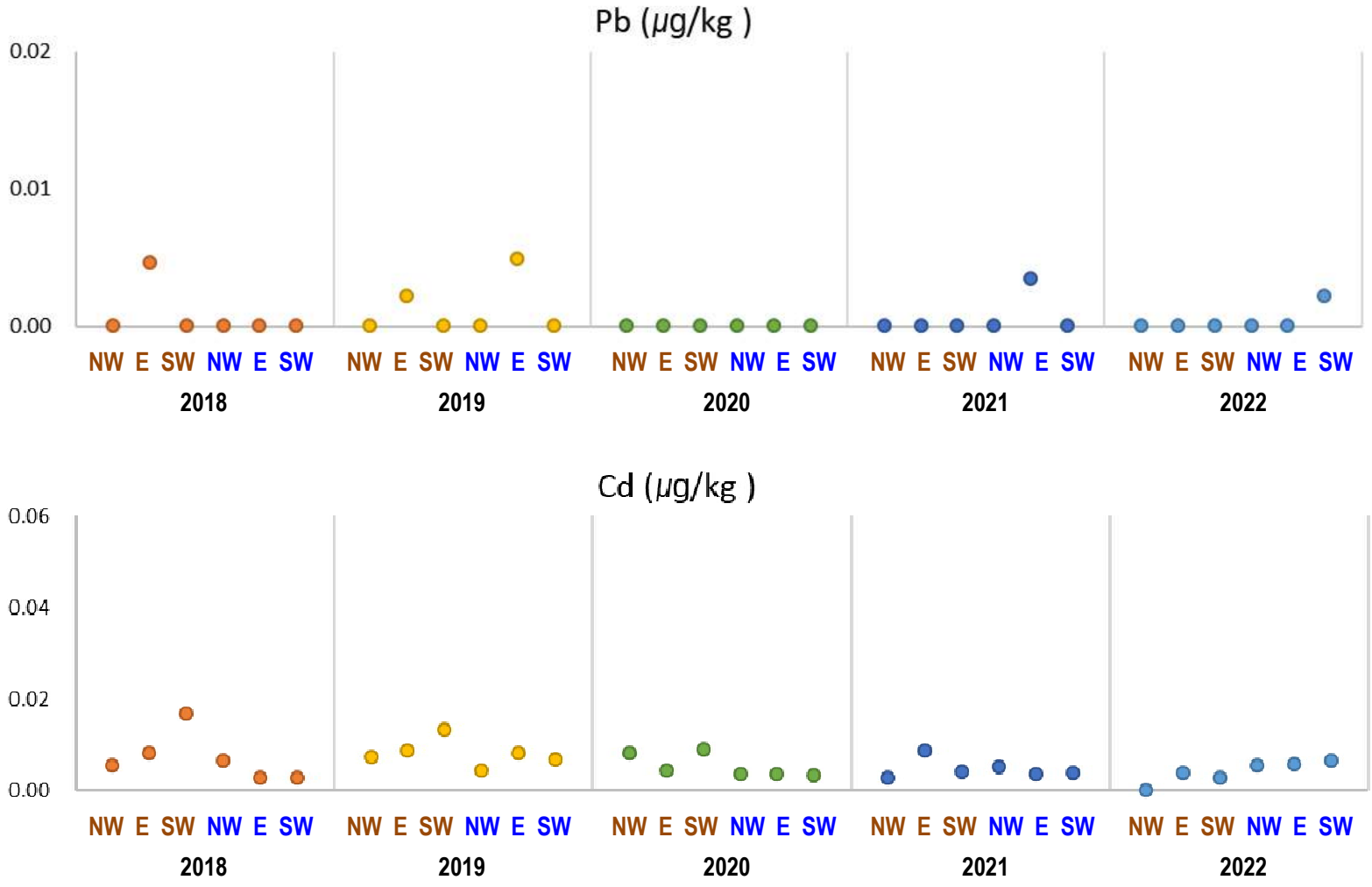
RESULTS

▶ Heavy metal content in rice by sampling site and season



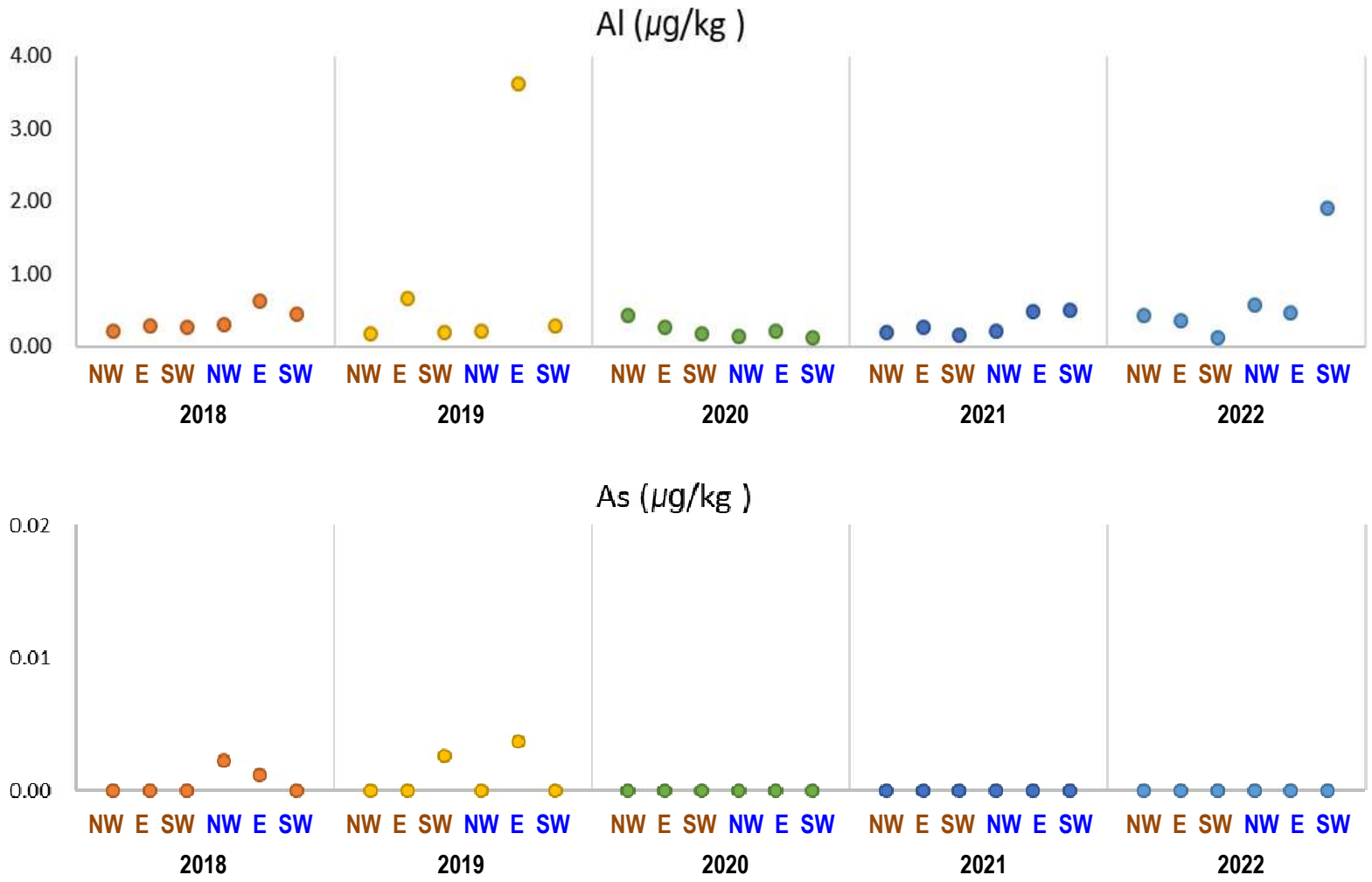
RESULTS

▶ Heavy metal content in napa cabbage by sampling site and season



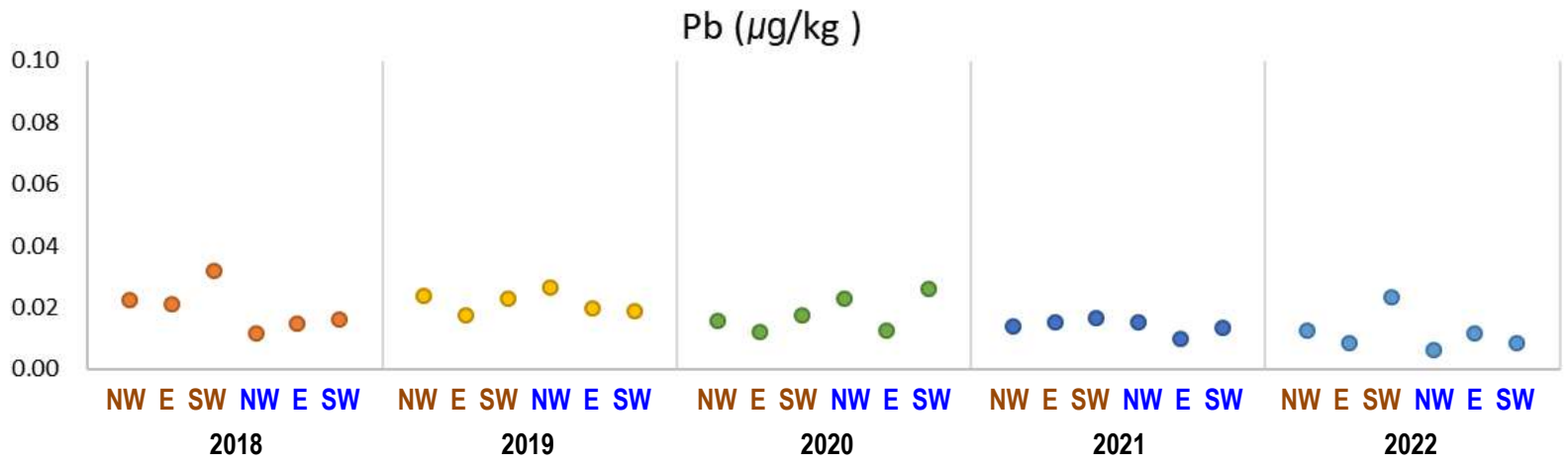
RESULTS

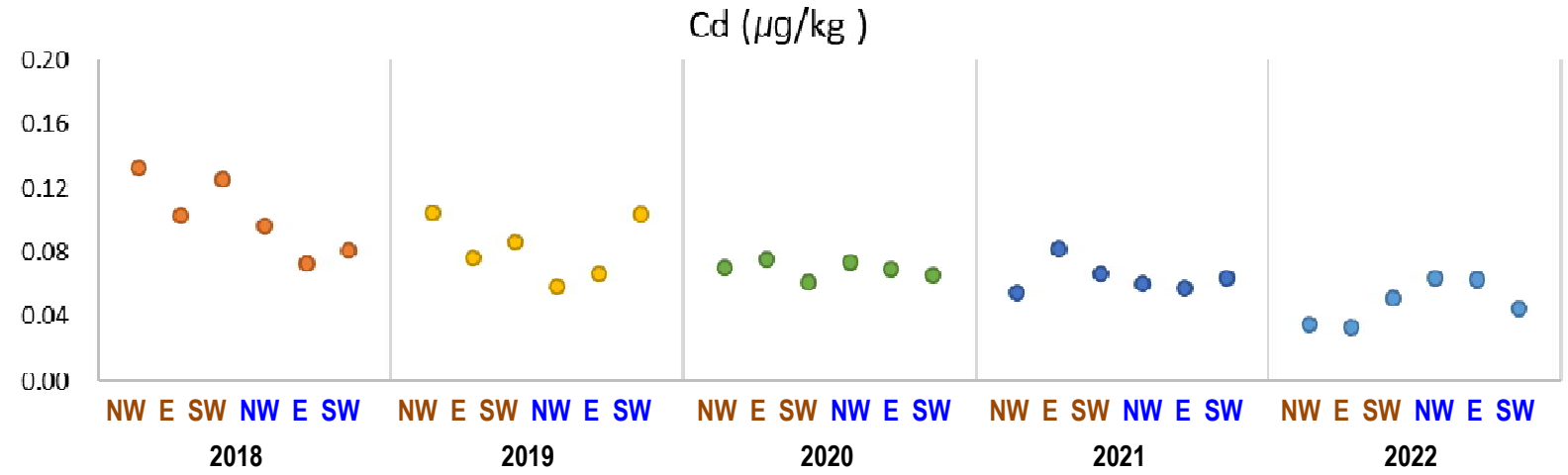
▶ Heavy metal content in napa cabbage by sampling site and season



RESULTS

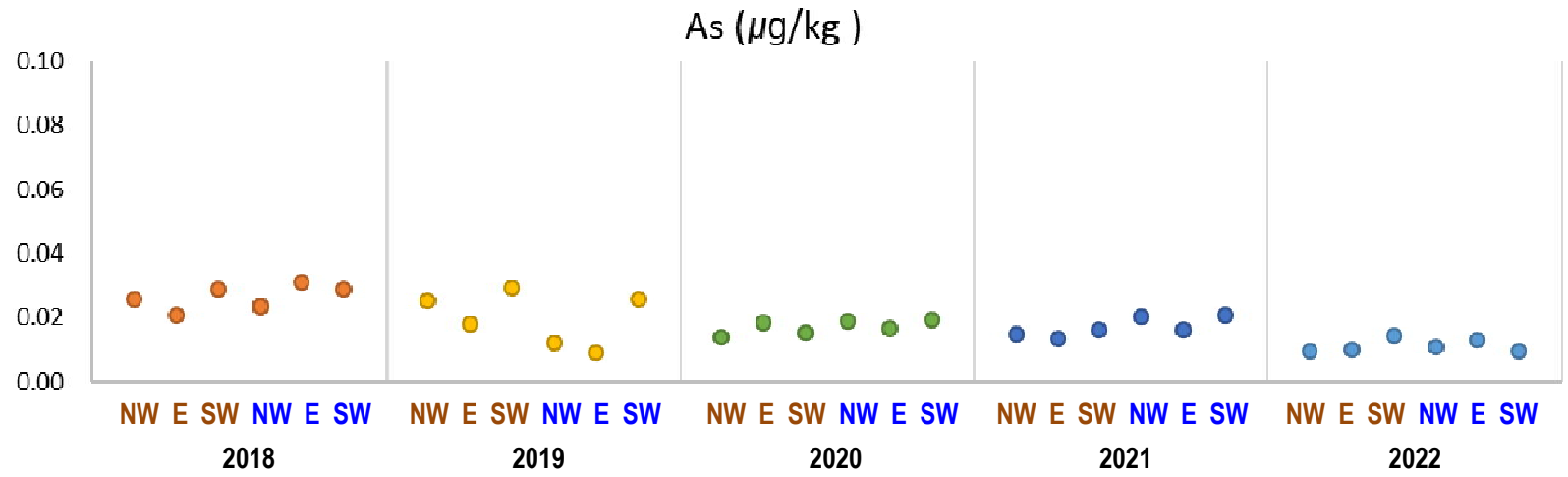
▶ Heavy metal content in red pepper powder by sampling site and season

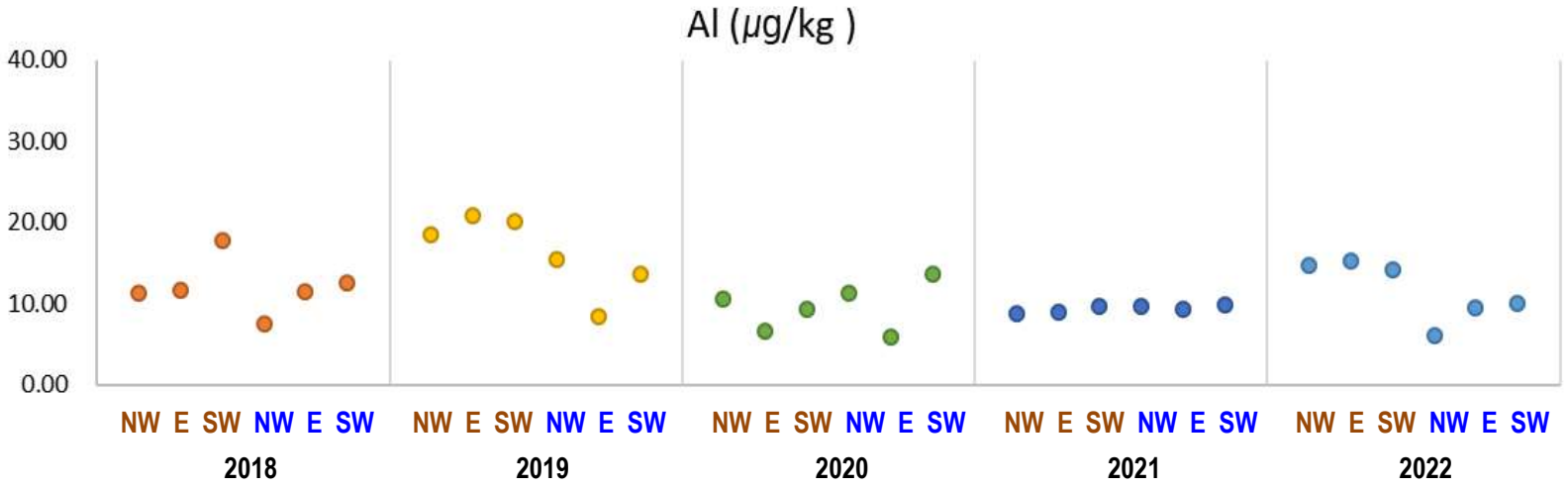




RESULTS

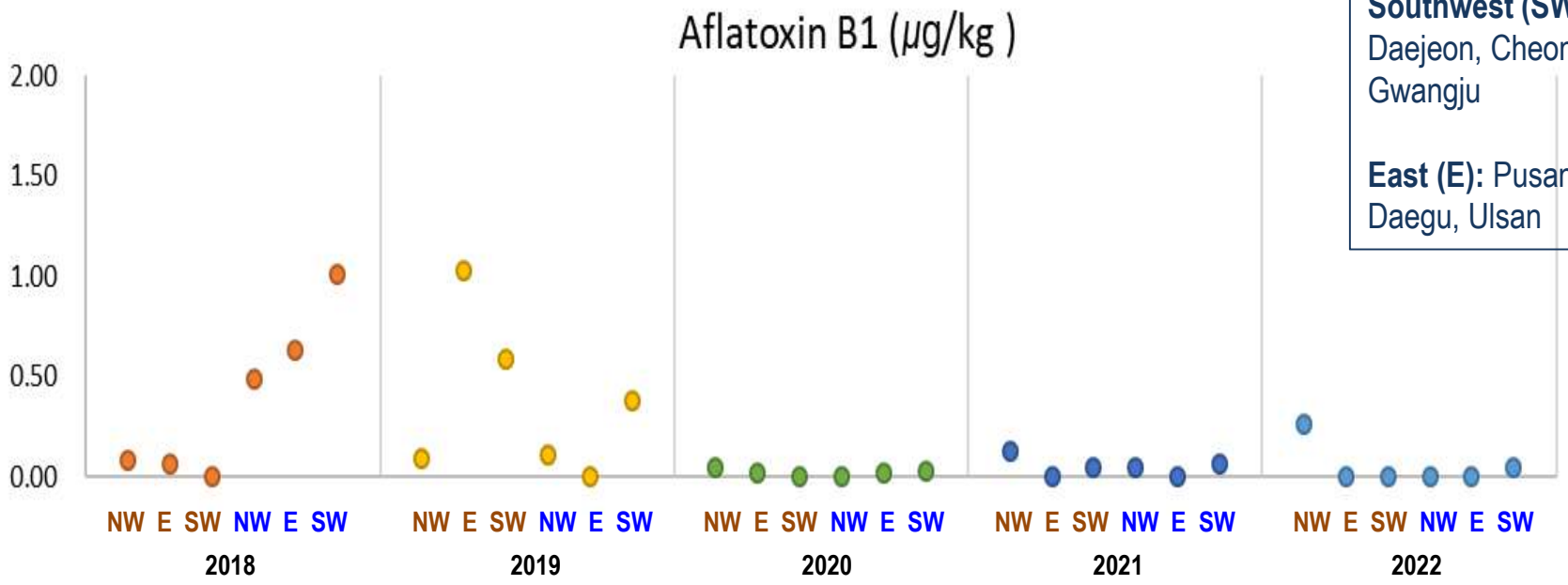
▶ Heavy metal content in red pepper powder by sampling site and season





RESULTS

▶ Aflatoxin B1 content in red pepper powder by sampling site and season



Northwest (NW): Seoul, Inchon, Suwon

Southwest (SW): Daejeon, Cheongju, Gwangju

East (E): Pusan, Daegu, Ulsan

RESULTS

▶ Some papers published

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RESEARCH ARTICLE

한국형 총식이조사에 근거한 우리 국민의 식품 기인 요오드 섭취량 추정

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Estimation of Dietary Iodine Intake of Koreans through a Total Diet Study (TDS)

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RESEARCH ARTICLE

Check for updates

우리 국민의 철 섭취량 평가: 식품별 영양성분 함량자료와 한국형 총식이조사 기반 추정량 비교

이지연[1),2)] · 권성옥[3)] · 여윤재[4)] · 서민정[2),5)] · 이계호[6)] · 김초일[7)†]

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Dietary Iron Intake of Koreans Estimated using 2 Different Sources of Iron Contents are Comparable: Food & Nutrient Database and Iron Contents of Cooked Foods in the Korean Total Diet Study

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서 울 대 학 교
SEOUL NATIONAL UNIVERSITY

RESULTS

▶ Some papers published

SPECIAL GUEST EDITOR SECTION

Analytical Method of Multi-Mycotoxins in Table-Ready Foods for a Total Diet Study Using Stable Isotope Dilution Liquid Chromatography–Tandem Mass Spectrometry

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Validation of analytical methods for heterocyclic amines in seven food matrices using high-performance liquid chromatography-tandem mass spectrometry

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ABSTRACT

Heterocyclic amines (HCAs) are potent mutagens generated by the high temperatures of the cooking process. The purpose of this study was to develop and validate analytical methods for HCAs determination using high-performance liquid chromatography-tandem mass spectrometry in seven food matrices: corn oil, milk, 20% ethanol, pork, flat fish, sea mustard (*Undaria pinnatifida*), and radish. Six isotopically labelled internal standards were used for quantitation, and Chem Elut and Oasis hydrphilic-liphophilic balance cartridges were applied for sample preparation to remove interferences. Calibration curves showed good linearity ($R^2 > 0.99$) in all matrices. The ranges of the method detection limit and method quantitation limit were 0.009–2.35 ng g^{-1} and 0.025–7.13 ng g^{-1}, respectively. The recoveries ranged from 67.5% to 119.6%. The coefficients of variation ranged from 0.3% to 15.1% for intra-day and ranged from 0.8% to 19.1% for inter-day. The methods were applied to 24 total diet study samples for HCAs quantitation. These results indicate that the established methods are reliable for determining HCAs in various foods.

ARTICLE HISTORY
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KEYWORDS
Heterocyclic amines; LC-MS /MS; method validation; total diet study

A Way Forward…

- The 1st Korean Total Diet Study will be completed by the end of 2022.
- The 2nd Korean Total Diet Study will be resumed from the spring 2023 for another 5 years possibly with some change in analytes.
- Any idea and/or suggestions on the stored sample utilization including international collaboration are welcome.

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THANK YOU!