別紙様式１１

（課程博士・論文博士共通）

論　文　要　旨

専攻名 （又は推薦専攻名）	地域イノベーション学専攻	氏　名（ふりがな）	鈴木 一平（すずき いっぺい）

学位論文題目：食品成分摂取量調査と食品添加物の新規測定法の開発に関するレギュラトリーサイエンス研究（英訳又は和訳：Regulatory science study on a food ingredient intake survey and development of new analytical methods for food additives）

In recent years, new scientific concepts that connect science and technology with the real world, e.g., regulatory science, green sustainable chemistry, and science communication, are rapidly evolving to establish harmony with the real world. Of these, regulatory science is a scientific field that was proposed in 1987 by Uchiyama with the following principal objective: “regulatory science is the science that reconciles the fruits of science and technology with the most desirable form for harmony between people and society.” Regulatory science is an interdisciplinary scientific field with a vast targeted research area. Within this area, one can find basic research grounding regulations related to things such as pharmaceuticals, food, and food additives, which play an important role in the prediction and evaluation of characteristics and impact when, once distributed in the market, these products are directly ingested into the human body. In particular, utmost attention should be paid to the basic research that ensures the safety standards of food and food additives that are ingested through meals every day. I herein used regulatory science to examine the results of an intake survey of aluminum present in foods and developed analytical methods for food additives on the basis of the following three studies.

1) Estimation of daily aluminum intake in Japan based on food consumption inspection results

Dietary aluminum (Al) intake by young children, children, youths, and adults in Japan was estimated using the market basket method. The Al content of food category (I–VII) samples for each age group was determined by inductively coupled plasma-atomic emission spectrometry. The Al content in processed foods and unprocessed foods ranged from 0.40 to 21.7 mg/kg and from 0.32 to 0.54 mg/kg, respectively. In the case of processed foods for all age groups, the Al content in sugar and confections/savories was the highest. The daily dietary Al intake from processed foods was much higher than that from unprocessed foods. The mean weekly percentages of the provisional tolerable weekly intake (PTWI; established by the joint FAO/WHO Expert Committee on Food Additives in 2011) from processed foods for young children, children, youths, and adults are 43.1%, 22.4%, 17.6%, and 15.1%, respectively. Only the highest consumer Al exposure value (>P95) of the young children group exceeded the PTWI.

2) Development of an analytical method for copper chlorophyll and sodium copper chlorophyllin in processed foods

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氏　名（ふりがな）	鈴木 一平（すずき いっぺい）

The food colorants copper chlorophyll (CuCh) and sodium copper chlorophyllin (CuCh-Na) are used worldwide in a wide range of processed foods. I developed an analytical method for the determination of CuCh and CuCh-Na levels in processed foods to effectively monitor the appropriate use of these colorants. The proposed analytical method involves simultaneous extraction and parallel analysis of hydrophobic CuCh and hydrophilic CuCh-Na without potentially harmful solvents. CuCh and CuCh-Na were extracted from processed foods with 1-butanol and ethyl acetate. CuCh-Na was extracted from the initial extraction solvent with 0.15 mol/L NaOH, and then, the residual extraction solvent and alkaline water layers were dried. Finally, the samples were carbonized with H_2SO_4. The carbonized samples were ashed in a muffle furnace at 480°C. The residue was dissolved in 0.1 mol/L HNO_3, and the level of copper in the samples was determined using atomic absorption spectrophotometry to indirectly quantify the levels of CuCh and CuCh-Na. The performance of the developed method was validated by a recovery test and application for commercial foods. The results indicated that the developed method has reliable precision and applicability for the determination of CuCh and CuCh-Na in commercial foods.

3) Development of analytical methods for residual materials of peracetic-acid-based sanitizers on uncooked foods

Peracetic-acid-based sanitizers (PAS) are antimicrobial agents that are widely used to treat uncooked foods because they are effective against a wide range of microorganisms. However, PAS had not been permitted to be used for food sanitation in Japan. Therefore, the residual materials of PAS on imported uncooked foods had to be monitored for the regulation. The residual materials of PAS components are 1-hydroxyethylidene-e1,1-diphosphonic acid (HEDP) and octanoic acid (OA). Therefore, the analytical methods of residual HEDP and OA on PAS-treated uncooked foods are developed in this study. The developed analytical method of residual HEDP on uncooked foods involves an ultrasonic extraction, a simple sample preparation, and an ion chromatograph with tandem mass spectrometry. The developed analytical method of residual OA on uncooked foods involves straightforward solvent extraction, derivatization with sulfuric acid/methanol, and gas chromatography coupled with mass spectrometry. These developed methods were validated via a recovery test and application to the PAS-treated various uncooked foods. The obtained result shows that these methods can be applied and are appropriate for determining residual HEDP and OA on PAS-treated uncooked foods for the regulation. Moreover, the developed determination method of OA was applied to imported uncooked foods (56 beef samples, 34 vegetable samples, and 89 fruit samples), and we found that OA levels ranged from 0.34 to 0.53 mg/kg, from the limit of quantification (LOQ, 0.02 mg/kg) to 0.48 mg/kg, and from LOQ to 1.12 mg/kg, respectively.