広島大学ホームカミングデー　生物生産学部・生物圏科学研究科企画

第 7 回 生物圏科学研究科 食料・環境問題国際シンポジウム
「アジア諸国における安全な食料生産環境の実現」

7th International Symposium on Food and Environment
"Environment of Food Security and Food Safety in Asia"

日　時：平成２６年１１月 １日（土）　13:00 – 16:30
場　所：広島大学生物生産学部 C206 講義室

Date: 1 November, 2014 (Sat.)　13:00 – 16:30
Venue: Room C206, Faculty of Applied Biological Science, Hiroshima University.

研究科長からのご挨拶

いつまでも地球で暮らせるように、急増する世界の人口を飢えさせない十分かつ安全な食料をいかにして確保するかは人類に課せられた直近の大きな課題です。

人類の生存に欠かせない食料は、農作物、畜産物、天然資源および養殖の水産物として供給されています。しかしながら、近年の地球温暖化や異常気象によって各地域の伝統的な農作物が栽培に適さなくなり、世界的には農地の砂漠化が進行しています。一方、アジアの一部地域ではいまだに工業排水、家庭排水が未処理のまま海に排出され、水産養殖にともなう残餌や排泄物による沿岸域の汚染も続いています。

このシンポジウムを通じて、東南アジアと日本における食料生産の健全で安定的な生産と、環境の保全、気象変動への対応と現状に関する情報を共有するとともに、日本が提供できる技術および教育などの協力についても、活発に意見交換ができることを期待しています。

研究科長　　植松　一眞

Greetings from the Dean

Living in a sustainable world today presents an urgent and tremendous challenge for humans in their effort to provide safe and secure food supplies to feed the rapidly growing global population.

Foods have supported the survival of mankind in the form of crops, farmed livestock as well as products of aquaculture and marine natural resources.　However, traditional crops in each region are threatened with extreme weather changes and global warming in recent years with desertification of farmlands becoming common around the world.　On the other hand, industrial effluents and domestic wastewater are being discharged without any treatment and the pollution of coastal areas by organic wastes and surplus feeds used in aquaculture goes on in some parts of Asia.

Through this symposium which seeks to share information on the current state of healthy food production in Japan and in Southeast Asia, environmental conservation and effective measures to address climate change as well as cooperation in education and technology developed in Japan can be discussed. I hope that the active exchange of ideas and opinions can be pursued in this symposium.

Prof. Kazumasa Uematsu, Dean

Program プログラム

General Chairperson 総合司会: Lawrence M. Liao

13:00 Opening Message 開会のご挨拶 Kazumasa Uematsu, Dean 研究科長 植松 一眞

13:05 Rationale of the Symposium 趣旨説明
Hiroshi Sakugawa, Vice Dean 副研究科長 佐久川 弘

13:10 "Environment of Food Security and Food Safety in Vietnam"
（ベトナムにおける食の安心・安全の現状）
Dr. Phan Tai Huan: Nong Lam University (Vietnam)
Chair 司会: Takuya Suzuki 鈴木 卓弥 ---Page 3

13:50 "Food Security in South Asia under Changing and Variable Climate: A case study from Sri Lanka"
（変動する気候下における南アジアの食料安全保障：スリランカからの事例研究）
Dr. Buddhi Marambe: University of Peradeniya (Sri Lanka)
Chair 司会: Toshinori Nagaoka 長岡 俊徳 --- Page 6

14:30 Coffee break 休憩

Reports of studies supported by the 2013 Grant-in-Aid for Research from the Graduate School of Biosphere Science 2013 年度研究科長裁量経費による助成研究成果報告

14:50 "Preparation of germinated paddy with high gamma- aminobutyric acid by soaking combined with anaerobic and fluidized bed heat treatment"
（嫌気処理と流動層熱処理を組み合わせた浸漬による高 GABA 発芽玄米の調整）
Dr. Ratiya Thuwapanichayanan: Kasetsart University (Thailand)
Chair 司会: Akihiro Ueda 上田 晃弘 --- Page 11

15:30 "Paralytic Shellfish Poison (PSP) –The Safety of Food from the Sea"
（麻痺性貝毒 -水産食品の安全性）
Dr. Manabu Asakawa: Hiroshima University (Japan)
Chair 司会: Tadashi Shimamoto 島本 整 --- Page 13

16:10 General Discussion 総合討論 Chair 司会: Hiroshi Sakugawa 佐久川 弘

16:25 Closing Remarks 閉会の辞 Kazuya Nagasawa, Vice Dean 副研究科長 長澤 和也

■**Reports of studies supported by the 2013 Grant-in-Aid for Research from the Graduate School of Biosphere Science, Hiroshima University**
2013 年度研究科長裁量経費による助成研究報告

Environment of Food Security and Food Safety in Vietnam

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In recent years, Vietnam is internationally recognized as one of the nations that has tremedous progress in solving the problem of hunger eradication and poverty reduction. Thanks to the proper orientation and development strategies towards agricultural modernization, Vietnam has been transformed from a country short of food to a major rice exporter and many other kinds of seafood and agricultural products. However, the agricultural production sector is also facing many challenges of the modern agriculture. Those are the desertification of agricultural areas, the excessive abuse of chemical pesticides and fertilisers, the effect of climate change to the agricultural production areas especially in the Red River Delta and Mekong Delta. In the country, there is an increasing of food poisoning, food safety outbreaks. Therefore, science and technology development as well as international cooperation in education and training play very important role in problem solving.

Overview of Vietnam food production and consumption

Located at the last part of Mekong River, Viet Nam has favorable natural conditions for agricultural development. Agriculture, forestry and fisheries, are important sectors of the economy, accounting for 18.4% of GDP in 2013. About 68 % of the populations live in rural areas. Agriculture therefore plays a crucial role in households' livelihoods. Viet Nam is currently the big exporter of many agricultural products such as rice, coffee, cashew, pepper, shrimp, fish, vegetables and fruit. However, Vietnam has also been a potential importer for dairy products, chilled and frozen beef, pork and poultry, fresh and dried fruits, snack foods and nuts, condiments, juices and alcoholic drinks. Vietnamese consumers are shifting their shopping from traditional markets to supermarkets, especially in urban areas. There are more and more western-style fast food outlets in Hanoi and Ho Chi Minh City.

The food security and food safety issues within the country

Food poisoning outbreaks

Despite of growing importance of health-conscious consumption, according to the statistics data of the Vietnam Food Administration, there are about 46 deaths, 5500 infected per year due to food poisoning in the last 5 years. In 2013, the rate of food poisoning in canteens of industrial parks, export processing zones accounted for 12 - 20.6% of all cases. Yet, there is not an efficiently surveillance system to record information of food outbreaks nationwide, so that the number of food poisoning cases under offically reported lower from real situation.

The common causes of food poisoning outbreaks in Viet Nam are (1) food contaminated with microorganisms, (2) toxins produced by microorganisms or naturally present in foods, (3) food additives abuse, (4) polluted environment, (5) chemical fertilisers and plant protection products. Foodborne pathogens account for 33-49% of all outbreak cases. The most common strains have been found are *Salmonella, E. coli, Clostridium perfringens, Listeria monocytogenes*. Besides the natural conditions of high moisture content and optimum environment temperature which are favorable for the growth of most bacteria, mould and fungi, the diveristy of foods with natural toxins range from plant products (cassava, mushroom, bamboo shoot…) to animal products (puffer fish, ocean fish, frog meat…) are among of causes of food poisoning.

Overuse of chemicals in food production

In order to boost productivity, there are more and more chemical fertilizers and plant protection products have been used in agriculture. Obviously, these chemicals act on pests but lead to adverse environmental impact. Strikingly, the understanding of the farmers of the harmful effects of plant protection chemicals and fertilizers on the environment and human health is limited.

In the livestock sector, the misuse of antibiotics, medications, growth hormones also caused concerns for public health. The recent report of the Viet Nam Ministry of Health revealed a high level of antibiotic resistance in Viet Nam patients. In particular, Viet Nam had high prevalence of penicillin resistance and erythromycin resistance. In terms of economics impacts, the misuse of antibiotics especially inhibited antibiotics in aquaculture and livestock sector more or less affects the prestige of Viet Nam’s export products.

Food loss and waste

The issue of food loss and waste has been drawing much attention of governments, policymakers and researchers. The loss and waste of food in the food chain fluctuates upon the kind of food commodities in the agricultural production. In Vietnam, food is lost during the stages of production, storage and transport. In vegetable production, there has been reported that 17% loss in postharvest activities. Whilst the percentage of loss in rice harvest in the Mekong Delta is about 5.6%, equivalent to 1.4 million tons per year.

Reducing food loss is among of ways to reduce hunger and improve income for farmers in Viet Nam. Government has policies calling for scientists, processors to improve the food processing technology, postharvesting technology and reuse of food waste for other useful purposes. One of the successful examples is the production of bio-diesel from the grease of Tra and Basa Fish in the south of Vietnam.

Climate change and its affection

It is worthy noting about the affect of climage change to the environment as well as public health in Vietnam as the country has been included as one of the most vulnerable areas in the world by the global warming. The estimated patterns of climate change lead to the rise of sea level, increase the salt-water intrusion area and extreme weather conditions and natural disaters. As most of the agricutural production activities located near coastal line, the country's food security is threatened. It is reported that by 2100 when the sea level rises to 100 cm, about 9.3% of Viet Nam's land area and 10% of the population would be affected. Being aware of the importance of the issue, the country's agricultural production including aquaculture and fisheries has to be more and more flexible to response to the situation.

Roles of education and training institutes on food security and food safety

Education and training activities play a key role in the itinerary to adapt to climate change and ensure food security. In late 2013, the Vietnamese Prime Minister approved the project on "Strengthening food safety information, education and communication capacity to assist efficient implemtation of the Food Safety Law and the National Strategy on Food Safety for period 2011-2020 with vision towards 2030". Besides the main purpose of the project is to enhance the awareness and knowledge of Vietnamese on food safety, at the same time, to promote the research activities, coordination, and cooperation towards integral solutions for the food safety issues.

As one of the leading education institutes in agriculture sector, Nong Lam University – Ho Chi Minh City (formerly University of Agriculture and Forestry) in general and the Faculty of Food Science and Technology in particular have been taking all efforts to contribute for those initiatives. The University encourages all research activities from upgrading in breeding and cultivation methods to postharvest technologies especially biotechnology solutions that help boost productivity in a sustainable manner. Likewise, Faculty of Food Science and Technology has been conducting many studies to best use of food commodities and bring more new, convenient and safety products to the Vietnam marketplace. Every year, the Faculty educates hundreds of students to supply the manpower for the food industry in the South of Vietnam. Especially, students graduated from the Advanced Education Program, associated with the University of California - Davis, have been showing good professional capacity to ensure food safety and hygiene in Vietnamese food industry.

At the moment, Nong Lam University would hope to collaborate with other universities and organisations at different levels to promote progress in agricultural research, technology transfer, improve professional capacity for staff and exchange education activities, especially in the field of food security and food safety.

Food Security in South Asia under Changing and Variable Climate:A case study from Sri Lanka

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Introduction

Agriculture and food systems face many challenges, making it more and more difficult to achieve its primary objective of meeting the world food demand with current trends of increasing competition for land, water and other natural resources by non-agricultural sectors. Population growth and changes in consumption patterns associated with rising incomes drive greater demand for food and other agricultural products, while global food systems face an intimidating set of unprecedented challenges and risks affecting the food security of the current and future inhabitants of the world. Food security is multidimensional and its sustainability needs to be achieved under a more extreme and also more uncertain future climate, too. This need is further exacerbated with the outcome of the Rio+20 conference on Sustainable Development held in 2012, initiating an inclusive intergovernmental process to prepare a set of Sustainable Development Goals (SDGs) in the post-2015.

The latest estimates of the Food and Agriculture Organization (FAO) of the United Nations indicate that about 805 million people are chronically undernourished in 2012–2014, reduced by more than 100 million over the last decade, and 209 million lower than in the period 1990–1992. In the same period, the prevalence of undernourishment has fallen from 18.7 % to 11.3 % globally and from 23.4 % to 13.5 % for developing countries. The FAO has also estimated that the world's population will reach 9.3 billion people by 2050 and 10.1 billion by 2100. Much of this increase is projected to come from the developing countries with a rapid population growth, including 39 countries in Africa, nine in Asia, six in Oceania and four in Latin America. To meet the world's increasing demand for food, an anticipated 70% boost in global food production will be necessary by 2050. Most of the growth in food production will need to come from increased yields and productivity rather than from the use of additional land – a challenge that was met in prior years. For the food system to become more productive, sustainable and reliable, agricultural raw materials should be grown where resources provide the greatest production efficiency and can be renewed, so that production can continue for many years.

Food Security

In most part of the world and especially in the developing countries, concerns regarding food security (including nutrition security)[1] and its related issues are vital for poverty reduction.

1 FAO (2009): Food and Agriculture Organization of the United Nations, Rome

Food security is a complex phenomenon that manifests itself in numerous physical conditions resulting from multiple causes. Analysis carried out by FAO[1] confirms that developing countries have made significant progress in improving food security and nutrition, but the progress has been uneven across both regions and food security dimensions. In South Asia, attainment of food security is a core problem confronting farming households, especially women and rural populations due to low productivity in staple crop production, seasonal variability in food supply as well as price fluctuations. These problems facing farming households come about as a result of overreliance on rain-fed agriculture, none or inappropriate usage of chemical inputs as well as inadequate improved varieties of crops and animal species.

Climate Change

Climate change, as the consequence of global warming and depletion of the ozone layer, has already being experienced across the world and is a major challenge to sustainable development. Estimates done by the Asian Development Bank (ADB)[2] indicate that South Asia on an average could lose nearly 2% of its GDP due to climate change by 2050. Among the South Asian countries, Maldives will be the hardest hit by climate change in GDP loss by about 2% by 2050, while Bangladesh, Bhutan, India, Nepal, and Sri Lanka are projected to face a loss of GDP to the level of 1.4%, 1.8%, 2.2%, and 1.2%, respectively.

The global food supply has already being affected by climate change, and adverse effects on food production in varying degrees in different eco-systems, and also on food security, poverty and malnutrition are predicted. This is a particularly important challenge for South Asia due to the greater significance of agriculture in this region. The ADB[1] also estimates that the changes in precipitation pattern (timing and amount) increase the likelihood of short-run crop failures and long-run production declines, posing a serious threat to food security.

Sri Lanka at a Glance

Despite several setbacks in the economy, Sri Lanka was able to maintain a growth rate of about 4-7.5 % during the recent past. In terms of the per capita income of an average Sri Lankan, the country is now falling in to the category of lower middle income countries following the classification of the World Bank. In the year 2013, the per capita Gross Domestic Product was 3280 US$[3] and the country aims at upgrading the per capita income to 4100 US$[4] by 2016. The country has a diverse natural resource base on which the country heavily relies to improve livelihoods, generate income and reduce poverty. Agriculture, including fisheries, is the backbone of economic growth that employs about 33% of the labour force (2.6 million) and has contributed 10.8% to the national GDP in 2013[2].

2 ADB (2014): Assessing the Costs of Climate Change and Adaptation in South Asia. Asian Development Bank.

3 Department of Census and Statistics (2013): Provisional data, Annual report

4 Mahinda Chinatana – Wonder of Asia (2010): Government of Sri Lanka National Policy Document

Climate change in Sri Lanka

Analysis of data over the past five decades has revealed that the temperature in Sri Lanka has increased at a rate of 0.01-0.03 °C. The results has also showed that the total quantum of rainfall has not changed over a given season or an year, however, the variability of rainfall received during the four rainy seasons (first inter-monsoon, south west monsoon, second inter-monsoon and the north-east monsoons) has increased and the onset of monsoon rains has been highly erratic (delayed mostly). Long term predictions made through simulation models in Sri Lanka and globally have indicated that the water availability would further decrease in the dry areas (dry areas becoming direr) and increase in the wet areas (wet areas becoming wetter) due to changes in the climate. This would have a direct, negative impact on the heart of the agriculture sector in Sri Lanka, *i.e.* the dry zone that mainly provide the staple food (rice) for Sri Lankans, resulting in drastic changes made to the cultivation patterns and resources use (climate change adaptation).

Food Security and Food Production in Sri Lanka

Ensuring food security (including nutrition security) is a key objective in Sri Lanka's development agenda by enhancing agricultural productivity (crops, animals and fisheries) and subsequent reduction in malnutrition[5]. In terms of food security, self-sufficiency in rice production has been the major strategy of agricultural policy since Sri Lanka gained independence in 1948, which also has supported generation of employment, and elimination of rural poverty. Sri Lanka reached the cherished goal of self-sufficiency in the year 2010 mainly due to the investments on research and development. The rice research outputs in Sri Lanka in the last half century further corroborates this contention in that, 1% increase in rice research investment increased rice production by 0.37% with an internal rate of return of 174% in a tariff protected regime and a benefit cost ratio of over 2,300[6]. The Global Food Security Index in 2014 has placed Sri Lanka in the 60th position out 109 countries[7] (based on affordability, availability, and quality & safety), three positions up from that of 2013 indicating its improved performance over the years in terms of achieving sustainable food security.

Farming in Sri Lanka is dominated by small holdings *i.e.* average size of holding is below 1.0 hectare. Majority of the farmers in the country are the heavily dependent on rain-fed agriculture. The area under irrigation as per cent of arable land is around 39% in Sri Lanka. Besides, the ever-increasing population, even at a rate less than 1% as at present and that the population is expected to reach 22.16 million in 2020[8], is a major challenge in supplying enough food to their basic daily demand in the future, and skewing the human:land ratio. Livelihood security, eradication of poverty, reduction in hunger, and sustainable and inclusive

5 Mahinda Chintana (2010): Department of National Planning. Government of Sri Lanka

6 Niranjan F (2004)" PhD Thesis, Postgraduate Institute of Agriculture, Peradeniya, Sri Lanka

7 http://foodsecurityindex.eiu.com/Index

8 Based on the calculation using FAOSTAT data 2009

growth of economy of the country would thus critically hinge on the future of agriculture. Three out of every four poor people live in rural areas and depend on agriculture either directly or indirectly for their livelihood. Food security of farming households is of serious concern if Sri Lanka strives to consolidate the macroeconomic gains as farmers who are vulnerable to food and nutritional insecurity have limited capacity to respond to agricultural programmes.

At present, the technology generation in agriculture faces the major challenges of increasing food production in a sustainable manner and improving farm family income in order to ensure household food and nutritional security, while at the same time conserving the natural resource base. After 33 years of civil war, Sri Lanka expands economically and consumers demand more, better and healthy food, a varied and resounding impact awaits for vegetable production and consumption, as well as the underlying vegetable seed market. The technological innovations can, not only boost vegetable production and consumption in the country but also help to generate farm employment, off-farm employment opportunities, and increase income and resource use efficiency of poor farmers.

Food Security as affected by Climate Change

Food production systems in South Asia are extremely vulnerable to climate change. Higher temperatures would reduce yields of desirable crops and encourage weed and pest proliferation. Changes in precipitation pattern (timing and amount) increase the likelihood of short-run crop failures and long-run production declines, posing a serious threat to food security[9]. Although there will be gain in some crops in some regions, the overall impacts of climate change on agriculture are expected to be negative and need to be much better understood. Increase in carbon dioxide concentration to 550 ppm has been estimated to increase yields of rice, wheat, legumes and oilseeds by 10-20%[10]. However, a one degree increase in temperature may reduce yields of wheat, soybean, mustard, groundnut, and potato by 3-7%. The yield losses are likely to be much higher at higher temperatures. Studies assessing the economic impacts of climate change on agriculture have focused mostly on impacts on cereal crops like rice and wheat.

Available evidence indicates that climate change results in a yield decline of approximately 14%, 44-49%, and 9-19% for rice, wheat, and maize respectively[10] in the South Asian region. According to the estimates of the Asian Development Bank[9] (ADB), increases in both temperature and carbon dioxide (CO_2) level in the tropical and subtropical regions of Bangladesh, Bhutan, India, and Sri Lanka would result in a decline in rice yield of as much as 23% by 2080. Extended dry spells and excessive cloudiness during the wet season can reduce coconut yield, with annual losses of US$ 32 million to US$ 73 million. However, during a high rainfall year, the economy could gain by US$ 42 million to US$ 87 million due to high

9 ADB (2014): Assessing the Costs of Climate Change and Adaptation in South Asia. Asian Development Bank.

10 Kavi Kumar KS, Karunagoda K, Haque E,.Venkatachelam L and Bahal GN (2012): Addressing Long-term Challenges to Food Security and Rural Livelihoods in South Asia. Working paper 75/2012, Madras School of Economics, India

coconut yields. Future projections on coconut yield suggest that production after 2040 may not be sufficient to cater to local consumption[11].

A new approach to sustain food security is thus a necessity by effectively drawing in ecological principles to improve the productivity and efficiency of agriculture and food systems while reducing negative environmental impacts. Substantial gains in productivity in agriculture and food systems can be realized through investment, innovation, policy and other improvements. Advancements in the productivity frontier, transformations in production systems and enhanced food and environmental safety are three goals to achieve by countries, and Sri Lanka is not an exception. New technologies will make it possible for sustainable agriculture to become the new global standard, but the main factors resisting this change are political will, lack of policy coherence at many levels, financing, governance and human behavior. Realizing these gains will require an exceptional level of collaboration among stakeholders in the agricultural value chain, including government, private sector, civil society groups, academia/scientists, farmers and consumers.

Increase in availability in diverse food items not only reduces hunger but also alleviates the multitude of problems that are associated with hidden hunger, such as hypertension, diabetics, and even cancer. This will undoubtedly reduce the cost of both public and private health services. Climate change has been well recognized phenomenon to affect all four dimensions of food security, namely food availability (i.e. production and trade), access to food, stability of food supplies, and food utilization. The importance of the various dimensions and the overall impact of climate change on food security will differ across regions and over time and, most importantly, will depend on the overall socio-economic status that the country has accomplished as the effects of climate change set in. Food security is linked to our ability to adapt agricultural systems to extreme events using our understanding of the complex system of production, logistics, utilization of the produce, and the socioeconomic structure of the community[12].

11 Eriyagama, N., Smakhtin V, Chandrapala L and Fernando K (2010): The Impacts of Climate Change on Water Resources and Agriculture in Sri Lanka: A Review and Preliminary Vulnerability Mapping. Colombo: International Water Management Institute.

12 IPCC (2012): Intergovernmental Panel for Climate Change, Geneva.

Preparation of germinated paddy with high γ-aminobutyric acid by soaking combined with anaerobic and fluidized bed heat treatment

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Rice is a staple food for about half of the world population. Over 90 percent of the world's rice is produced and consumed in Asian countries with annual consumption per capita of around 80-90 kg. Recently, rice consumption in the middle and high-income Asian countries, such as Japan, Taiwan and the Republic of Korea has been decreasing. Therefore, novel rice utilizations are necessary to enhance rice consumption and maintain the paddy field, which is important to preserve the environment.

Germinated rice is one of the novel rice utilizations; it has been becoming a popular healthy food because it contains high contents of nutrients and bioactive compounds, especially γ-aminobutyric acid (GABA). GABA functions as a neurotransmitter in the brain. It has ability to prevent Alzheimer's disease, cure insomnia, lower blood pressure and inhibit cancer cell proliferation.

GABA is generated by the decarboxylation of glutamic acid, catalyzed by glutamate decarboxylase, which occurs during germination process. Germinated rice is conventionally performed by soaking brown rice in water for a certain time until its embryo begins to bud, preferably a length of 0.5-2 mm. During soaking, the hydrolytic enzymes are activated and hence decompose the high-molecular weight compounds, such as starch, non-starch polysaccharides and proteins, to small-molecular weight compounds, resulting in an increase in reducing sugar, peptides and amino acids, including GABA. GABA is accumulated in the germ or embryo. The decomposition of starch in germinated rice leads to easy cooking and its texture is softer and stickier than that of un-germinated rice. Therefore, various foodstuffs, such as rice-balls, rice bread and soups, have been developed using germinated brown rice as primary material. The number of germinated brown rice products is increasing on the Japanese food market.

Recently, soaking paddy in water has been used to produce germinated rice. It could shorten the soaking time in comparison with soaking brown rice. Moreover, the GABA content in the germinated rice prepared from paddy (GP) was higher than that of the germinated rice prepared from brown rice (GBR). This is due to the fact that the accumulated minerals in the hull provide greater hydrolytic enzyme activities, leading to a higher GABA generation.

The GABA content in plant tissues could be increased by a variety of stresses, such as heat shock, mechanical stimulation, hypoxia and phytohormones. In this study, soaking combined with anaerobic treatment (SA) and soaking combined with anaerobic and heat treatment

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(SAH) methods were used for germinating paddy and compared with conventional soaking (CS) method. However, there are still some problems for germinated rice from the viewpoint of safety and food sanitation. Microorganisms can grow during germination process due to the availability of nutrients and excess water in the grains, it is necessary to prevent microorganisms growth by steaming and drying. In this study, the fluidization technique was used for drying GP. The qualities of GP prepared by CS, SA and SAH methods after shade drying and fluidized bed drying in terms of GABA content, number of fissured kernels, textural properties and number of microorganisms were subsequently investigated.

The experimental results showed that germination of paddy by SA and SAH methods required shorter germination time in comparison with CS method. In addition, the SA and SAH methods could enhance GABA content in the GP. The GP prepared by SAH method had the highest GABA content, followed by SA and CS methods, respectively. The GABA contents in GP prepared by CS, SA and SAH methods were increased by 15, 25 and 29 times of un-germinated brown rice, respectively. Although the amount of GABA was high, the shade-dried GP prepared by SA and SAH methods had a higher number of fissured kernels than that prepared by CS method. The subsequent head brown rice yield of samples prepared by both methods became lower than that of sample prepared by CS method. The texture of the GP prepared by SA and SAH methods for the complete kernel was harder than that of the GP prepared by CS method whilst the stickiness of the GP prepared by the three germination methods was not significantly different. Fissure of kernels affected the hardness but affected the stickiness insignificantly. The hardness values of fissured kernels obtained from SA and SAH methods were slightly lower than those obtained from CS method.

After fluidized bed drying at 150^{o}C, the GABA content in GP did not degrade, but the number of fissured kernels of fluidized bed dried samples was higher than that of shade-dried samples. Fissure characteristic for all thermally-dried samples appeared mainly in the form of a single fissure along the transverse axis whereas the fissure for all shade-dried samples appeared mainly in the form of multiple fissures except the fissure of sample prepared by CS method. Hence, the head brown rice yield of the fluidized bed dried samples was higher than that of the shade-dried samples. Hardness and stickiness values of the fluidized bed dried samples prepared by the three germination methods were not significantly different except the hardness value of the complete kernels obtained from CS method. It was softer than that obtained from SA and SAH methods. The number of microorganisms, including bacteria, yeast and moulds in GP prepared by SAH method was also determined in this study. It was found that the numbers of bacteria, yeast and mold in the fluidized bed dried samples were safe for consumption. From this study, it is recommended that the SAH is an effective method to produce GP with a high GABA content.

Keywords: Anaerobic treatment; fissure; γ-aminobutyric acid; germinated paddy; heat treatment

Paralytic Shellfish Poison (PSP) –The Safety of Food from the Sea

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1. Introduction

Paralytic shellfish poison (PSP), one of the most notorious and hazardous marine biotoxins known, is produced by toxic marine dinoflagellates species of the genera *Alexandrium*, *Gymnodinium*, and *Pyrodinium*, and is accumulated in many species of marine filter-feeding organisms such as bivalve mollusks through the food chain. The first PSP toxin was isolated from the Alaska butter clam *Saxiomus giganteus* and it was designated saxitoxin (STX) later. Subsequent studies showed that PSP is not composed of STX alone, but at least further 20 derivatives whose structures are closely related to each other with a range of hydroxyl, carbamyl, and sulfate moieties at four sites on the backbone structure. The carbamate toxins have the highest toxicity, and they include STX, neoSTX, and gonyautoxin (GTX1-4). The decarbamoyl toxins (dcSTX, dcneoSTX, dcGTX1-4) have intermediate toxicity and are reported in bivalves, but are not commonly found in toxic dinoflagellates. The *N*-sulfocarbamoyl toxins (B1 [GTX5], B2 [GTX6] and C1-4) are less toxic. The minimum lethal dose (MLD) of PSP in humans is estimated to be 3,000 mouse unit (MU) based mainly on fatal cases induced by this toxin. One MU of PSP is defined as the amount of this toxin which can kill a 20g ddY strain male mouse in 15 min, after intraperitoneal administration. The quarantine limit is set at 4 MU/ g edible part, a value which is essentially the same as that in USA and Canada. This presentation summarizes the role of some marine organisms as vectors of PSP and discusses the need for the surveillance to protect public health and ensure quality of seafood products. Several case studies pertaining to management actions to prevent food poisoning incidents from PSP accumulation in filter-feeding (traditional) and non-filter feeding (non-traditional) vectors of PSP are included.

2. Accumulation of PSP by Filter Feeding (Traditional) Vectors

2.1. Toxic Dinoflagellate and PSP-Infested Bivalves

In April, 1992, paralytic toxicity exceeding the quarantine limit of 4 MU/g edible parts as PSP was detected suddenly in bivalves such as oysters, mussels and short-necked clams from Hiroshima Bay concomitantly with the appearance of the toxic dinoflagellate *A.tamarense*. The toxicities were 31.4 MU/g for oysters, 214.6 MU/g for mussels and 20.3 MU/g for short-necked clams on 22nd April. Consequently, the toxin was found to be comprised of

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GTX1-4 as the major components, which accounted for approximately 92-95 mol% of all components, with a trace of STX. It was concluded from these results that the toxin of the bivalves collected in Hiroshima Bay in April, 1992 consisted predominantly of PSP, possibly derived from the toxic plankton *A. tamarens*e detected there.

2.2. PSP-Infested Marine Mossworm

During the screening for paralytic potency in marine organisms, a lethal potency in a brown seaweed and also in the shell of scallop, both of which were fouled with organisms inclusive of mossworm. In addition, raw fouled seaweed was collected from the same bay in July, 1990 from Funka Bay, Hokkaido, Japan. In summer of 1990, the mossworm from a raw alga exhibited a score of 2.4 MU/g. The toxin composed of GTX1, 2, 3, 4 and neoSTX, whose molar ratios were 4:3:9:1:6. GTX1-3 and neoSTX are main components, with the 1990 sample. Mossworm toxin was identified as PSP which was composed mainly of GTX1, 3 and neoSTX. Since the mossworm is a filter-feeding organism, this suggested that mossworm toxin could have come from *A. tamarense* through the food chain.

3. Accumulation of PSP by Non-Filter Feeding (Non-Traditional) Vectors

3.1. Carnivorous Gastropod

During surveillance on the toxicity of invertebrates such as bivalves inhabiting the coasts of Hiroshima Bay in 2001 and 2002, the carnivorous gastropod rapa whelk *Rapana venosa* collected in the estuary of Nikoh River was found to contain toxins which showed paralytic actions in mice; the maximum toxicities as PSP were 4.2 MU/g (May 2001) and 11.4 MU/g (April 2002). It was comprised of high toxic component (GTX3, 2, and STX) as the major components, which accounted for approximately 91 mol% of all components along with C1, 2. Judging from their toxin patterns, it is suggested that the PSP toxification mechanism of the gastropod that PSP toxins produced by *A. tamarense*, are transferred to and accumulated in plankton feeders, and then transferred to this carnivorous gastropod through predation.

3.2. Herbivorous Gastropod

Toxicity in excess of the quarantine limit as PSP was detected in ormer, *Haliotis tuberculata*, imported from Vigo, Spain, to Japan, between January and April, 1994. Foot was the most toxic in all of six specimens (32.9-106 MU/g), followed by the epipodium of the foot (14.3-30.9 MU/g) and mouth (11.4-33.2 MU/g), while right shell muscle (3.2-8.2 MU/g), digestive gland (2.0-3.7 MU/g), and viscera (4.2-15.6 MU/g) were less toxic. The muscular tissues were highly toxic, in comparison with the visceral ones. The ormer toxins apparently comprised members of STX group, such as STX, neoSTX, and decarbamoylSTX (dcSTX). Regardless of the tissue, dcSTX was the principal component, accounting for 83 mol% (epipodium of foot) to 97 mol% (digestive gland) of all components.

4. Conclusion

PSP produced by toxic dinoflagellates is transferred and bioaccumulated throughout aquatic food webs, and can be vectored to terrestrial biota, including humans. PSP, which comprise STX and its related compounds, are responsible for the sometimes fatal toxic seafood related syndromes. PSP poisonings typically results from the consumption of filter-feeding bivalves that concentrate toxins from bloom-forming microalgae – mainly marine dinoflagellates. As the occurrence of several new non-filter-feeding (non-traditional) vectors of PSP other than bivalves and secondary intoxication of edible gastropods are huge problems from the view point of food hygiene as well as fishery, legislation should be adjusted to extend the monitoring of marine biotoxins to a wider range of species besides commercially important edible bivalves. Among non-filter feeding, non-molluscan species, STX group has been found most commonly in xanthid crabs. Further studies are now in progress to elucidate the mechanisms involved.

Keywords: paralytic shellfish poison; saxitoxin; gonyautoxin; *Alexandrium tamarense*; dinoflagellate; vector; filter-feeding; bivalve; gastropod; xanthid crab

平成２５年度

研究科長裁量経費による研究助成

成果報告書

平成２６年１１月１日

広島大学大学院生物圏科学研究科

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基盤研究サポート Grant-in-Aid for Fundamental Research	卸売市場システムが地域経済に及ぼす影響の研究 －広島県農水産業と広島市中央卸売市場を中心として－ The Effect of the Wholesale Market System on Regional Economy: A Case Study of Hiroshima	矢野　泉 Izumi Yano	300
基盤研究サポート Grant-in-Aid for Fundamental Research	広島県の条件不利地域におけるワークショップ開催による地域戦略の構築支援 Support for less-favored area in order to make rural strategies with holding workshops in Hiroshima prefecture	細野　賢治 Kenji Hosono	300
基盤研究サポート Grant-in-Aid for Fundamental Research	ニワトリのストレス反応と性格関連遺伝子多型との関係 Polymorphism Associated with Stress-Related Behavior in Chickens	豊後　貴嗣 Takashi Bungo	300
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The Effect of the Wholesale Market System on Regional Economy: A Case Study of Hiroshima

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卸売市場システムが地域経済に及ぼす影響の研究
－広島県農水産業と広島市中央卸売市場を中心として－

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本研究の目的は、生鮮食料品流通の拠点となってきた卸売市場の存在意義を、地域経済との関連において、機能面及び経済的波及効果の面から明らかにすることである。具体的事例地域として、産地としては小規模多品目産地、都市規模としては中規模都市圏を抱える広島県を中心に検討した。また、この目的に到達するために、①産地と卸売市場の取引上の力関係、②大産地と中小卸売市場の取引条件、③小規模多品目産地と大規模（拠点的）市場の取引条件に注目し、小規模多品目産地に位置する卸売市場としての広島市中央卸売市場の機能の解明と、卸売市場取引の質的量的変化が地域の農水産業へ与える経済的影響を明らかにすることを試みた。主な研究方法は、生鮮食料品流通に関わる統計分析と卸売市場及び産地出荷団体への聞き取り調査である。

その結果、上記①については、高齢化等農業生産力全体の縮小を背景に、産地による卸売市場の絞り込み傾向がみられること、すなわち取引交渉において産地側の力が大きくなる傾向が明らかになった。生産量が減少する各主産地では、より有利な取扱いや資金回収リスクの低い卸売市場を出荷先として絞り込み、結果として、東京都中央卸売市場大田市場や大阪市中央卸売市場本場等、大都市の中央卸売市場への卸売荷の集中が進んでいる。そのため、②について、それ以外の中規模、小規模の卸売市場（例、広島市中央卸売市場）においては、大産地から卸売荷が集まりにくい現象が生じている。また、そうした卸売市場においては、荷を集めるために、大都市中央卸売市場からの転送荷や買付集荷が多くみられるようになっている。一方、③広島県のような小規模多品目産地の農水産物は、大規模卸売市場に向けて規格別に一定量の商品を揃えることが困難なため、特徴的な一部の商品を除いて大規模中央卸売市場への出荷は難しくなっている。

こうした状況下において、広島市中央卸売市場は、大産地からの荷の確保の困難、後背生産地の縮小にともなう地場荷の減少という集荷面での課題が大きいことが明らかになった。また産地としての広島県は、近年レモンの需要が高くなっており、それについては東京や大阪の大都市圏への卸売市場出荷があるものの、他の品目については大都市圏への出荷が困難であることが明らかになった。例えば、東京都中央卸売市場への産地Ｓの早生及び普通温州ミカンの出荷は、レモン出荷とのセットでのみで可能となっている事例がみられた。一方、地場産品については、県内産地Ｙの普通温州みかんの卸値は、他の市場での取扱量が少ないこともあり広島市中央卸売市場での取引価格が最も高く評価されている。

以上のことから、広島市中央卸売市場と広島県の農水産業の今後の課題として、広島市中央卸売市場における地場産品の取り扱いの強化と、そのための産地の育成や支援が重要である。これまで卸売業者は商品評価や分荷が重要な機能であったが、すでに卸売業者の一部が地場産地と連携し産地支援に取り組み始めているように、生産過程への関心や生産者との連携による商品づくり及びそれら商品の川下への提案といった機能も重要となる。また、中央卸売市場を設置している広島市や、県内の卸売市場全体を監督する広島県等の行政も、農林水産業担当部門と卸売市場担当部門が連携して卸売市場振興を進めていくことが必要である。

広島県の条件不利地域におけるワークショップ開催による地域戦略の構築支援
Support for less-favored area in order to make rural strategies with holding workshops in Hiroshima prefecture

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本研究の目的は、わが国の農山漁村に与える社会経済的インパクトが大きい経済のグローバル化の下で、条件不利性の克服のために内発的発展を呼び起こす総合的かつ統合的な地域戦略を構築し、それを実行可能にする組織体制と自立支援のあり方を明らかにすることである。

そのために、中山間地域と島嶼部といった自然条件の不利な地域を対象として、①実態調査による社会経済的環境とその変化の状況把握、②これらをもとに個々の農山漁村における戦略の検討、③次の段階として農山漁村間の連携を促す広域的な戦略の検討を行うという計画のもとで本研究を進めている。研究対象地は広島県であるが、中山間地域および島嶼部から社会経済状況の異なる町（地域振興が比較的進んでいる「Ａ」地域とそうでない「Ｂ」地域）をそれぞれ取り上げて、取組状況の比較を試みようとしている。そのため、中山間地域では前者を世羅町、後者を安芸太田町として、島嶼部では前者を大崎上島町、後者を呉市豊町（大崎下島）として事例分析を行った。2013 年度は、先に示した研究計画の第一段階である「状況把握」のための聴き取り調査およびワークショップを行った。

世羅町は中山間Ａ地域と位置づけた。2013 年 3 月末の人口は 17,732 人、65 歳以上の占める比率は 37%である。世羅町では世羅高原 6 次産業推進協議会が旧世羅郡 3 町の共同で 1998 年に設立され、翌年に世羅高原 6 次産業ネットワークに発展した。現在の加盟団体は 60 を超え、観光農園、直売所、農産物加工グループのほかに、地元高校やレストランなども当ネットワークに加入し、地域が一体となって全町「農業公園」化をめざして 6 次産業化に取り組んでいる。

安芸太田町は中山間Ｂ地域と位置づけた。2013 年 3 月末の人口は 7,223 人、65 歳以上の占める比率は 45%である。安芸太田町では町長を議長とする未来戦略会議を 2010 年に立ち上げ、地域再生、産業再生、観光再生の 3 つの分野に分かれて町民、町職員および農林業、産業および観光関係の団体による協働で計画案を作成してきた。集落再生では集落ごとのマスタープラン作成、産業再生では農林漁業を再生するための 6 次産業化の取組、観光再生では森林セラピー基地認定への取組などが検討された。2012 年には観光協会と町役場が協働して教育旅行における民泊の受入を開始している。

大崎上島町は島嶼部Ａ地域と位置づけた。2013 年 3 月末の人口は 8,231 人、65 歳以上の占める比率は 44%である。大崎上島は広島県を構成する主要な島嶼のうち、唯一、本州との架橋が実現されていない。しかしながら、農業部門では農事組合法人シトラスかみじま、水産業部門では海藻塾にみられるように、Ｕ・Ｊ・Ｉターン者を取り込んで地域産品の高付加価値化や 6 次産業化をすすめて地域内所得の向上に努めている。また、2012 年には町役場が主体となって、教育旅行における民泊の受入を開始している。

呉市豊町（大崎下島）は島嶼部Ｂ地域と位置づけた。2013 年 3 月末の人口は 2,209 人、65 歳以上の占める比率は 62%である。かつては、「大長ミカン」に象徴されるように、明治時代から続く広島県では先進的なミカンの銘柄産地として知られ、多くの農家が島外に園地を確保して出作をするなど、活気あふれる島であった。現在は農業を取り巻く環境変化と社会状況の変化などによってミカンによる収入が減少し、高齢化・後継者不足は深刻である。最近では、都市住民に対して当該地域の状況をまずは理解してもらおうという意図のもと、地元住民によって都市農村交流を推進するための組織が立ち上がり、活動を開始している。

これら 4 地域における社会経済的状況を整理すると、地域戦略の構築が遅れている地域は、条件不利性の高さにもかかわらず、かつて経済的に豊かであった時期が存在し、その経験から脱却できないでいるという状況を浮き彫りになった。今後、地域戦略を構築するにあたっては、これをどのように評価するかも含めて、地域内外の両視点から検討することが重要である。

ニワトリのストレス反応と性格関連遺伝子多型との関係
"Polymorphism Associated with Stress-Related Behavior in Chickens"

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ヒトを含めた動物の性格（気質）と遺伝との関係については、ゲノム・サイエンスの進展によって、多くの知見を得るに至っている。家畜においても、性格（気質）に関連する遺伝子の変異（多型）に関する報告はあるものの、それら変異と実際の表現型（性格（気質）を伴う行動様式など）との関係については、ほとんど調査はなされていない。本研究では、鶏の気質の分類指標を構築することを目的として、2つの行動実験を行ない、鶏の気質に関連する行動反応性について品種・系統間で比較するとともに、性格関連遺伝子の変異との関係についても調査し、鶏の「気質（性格）」の評価基準策定を試みることとした。

【材料および方法】

供試動物：兵庫シャモ（831 および 833 系統）、土佐九斤および比較対照として卵用鶏（ジュリアライト）の雄ヒナ、各 20−30 羽を供試した。

ストレス反応試験：①トニック・インモビリティ (TI) ・テスト：群飼ケージからヒナを1羽取り出し、直ちに仰向けにして 15 秒間ほど保定したのち、静かに手を離し解放した。測定項目は、解放後の不動状態持続時間とした。また、持続時間が 5 秒以下であった場合は、改めて 15 秒間の保定をおこなって再試行した。試行は4回までとし、この回数を試行点数として記録した。4試行でも不動姿勢をとらない場合は、試行回数5回、姿勢持続時間0とした。また、姿勢持続時間は最長10分までとした。②マニュアル・リストレイン (MR) ・テスト: ケージからヒナを1羽取り出し、その右胴および両脚を捕捉した後、鶏のもがき開始時間（初動時間）およびその回数を計測した。なお、捕捉は5分間行った。

遺伝子多型解析：試験鶏から採取した血液から DNA を抽出し、目的の遺伝子多型を含む領域を PCR 法にて増幅した後、RFFP 解析を行った。対象とした遺伝子および一塩基多型は成長ホルモン放出因子受容体（GHSR）の c.739+726 T>C とした。

統計処理：統計学的検定は、Kruskal-Wallis 検定を行うとともに、Steel-Dwass の多重比較検定によって、群間の差の検定を行った。さらに、各鶏の測定項目について主成分分析を行って、品種・系統間の違いについて検討した。

【結果】

1. TI テスト: 試行回数は、831 系統（30 羽）：1.1±0.1、833 系統（27 羽）：1.3±0.1、土佐九斤（22 羽）：1.5±0.2 および卵用鶏（20 羽）：1.1±0.1 となり、品種・系統間に大きな違いは認められなかった（P=0.059）。一方、姿勢持続時間（秒）は、831 系統：150±38、833 系統：55±14、土佐九斤：82±14 および卵用鶏：240±41 となり、卵用鶏において最も長いことが示された。また、831 系統を除く 833 系統、土佐九斤および卵用鶏の間に有意な差が認められた（P<0.001）。

2. MR テスト: 初動時間（秒）は、831 系統：151±18、833 系統：119±19、土佐九斤：147±20 および卵用鶏：175±21 となり、大きな違いは示されなかった（P=0.167）。総もがき回数は、831 系統：3.5±0.6、833 系統：4.1±0.7、土佐九斤：2.5±0.4 および卵用鶏：7.1±1.0 となり、卵用鶏において最も回数の多いことが示された（P<0.001）。

3. 主成分分析: 第1主成分の寄与率は 42.6%、第2主成分の寄与率は 29.4%であり、これら2主成分による累積寄与率は 72.0%であった。第1主成分の因子負荷量は初動時間が 0.922、もがき回数が−0.923 であったことから、第1主成分は MR テストにおける反応が因子であると解釈された。第2主成分では試行回数が 0.746、姿勢持続時間が−0.782 となり、TI テストにおける反応が因子であると解釈された。しかし、各個体の分布からは品種・系統間の違いを明確に示すには至らなかった。姿勢持続時間について

4. 遺伝子多型と行動反応: 調査鶏の GHSR 遺伝子に認められた対立遺伝子型頻度は、TT 型 73.68%、TC 型 25.33%、CC 型 0.06%で、対立遺伝子頻度は、T 対立遺伝子が 0.863、C 対立遺伝子が 0.127 であった。各調査項目に対する GHSR 遺伝子型の効果について検定を行ったところ、姿勢持続時間おいて有意な差が認められた（P<0.05）。

【まとめ】

以上の結果から、TI テストの姿勢持続時間および MR テストのもがき回数が、品種・系統間差の分類指標となること、GHSR 遺伝子の対立遺伝子 C は相加的に姿勢持続時間を短くする効果があることが示唆された。しかし、2試験4項目のみでは、品種・系統間の気質・行動特性を明確に分離するには不十分であるものと考えられた。