7

7th International Symposium on Food and Environment

"Environment of Food Security and Food Safety in Asia"

13:00 – 16:30

: C206

Date: 1 November, 2014 (Sat.) 13:00 – 16:30

Venue: Room C206, Faculty of Applied Biological Science, Hiroshima University.

Greetings from the Dean

s. 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.

Pro

f. Kazumasa Uematsu, Dean

Program

General Chairperson : Lawrence M. Liao

13:00 Opening Message Kazumasa Uematsu, Dean

13:05 Rationale of the Symposium

Hiroshi Sakugawa, Vice Dean

13:10 "Environment of Food Security and Food Safety in Vietnam"

Dr. Phan Tai Huan: Nong Lam University (Vietnam)

Chair : Takuya Suzuki ---Page 3

13:50 "Food Security in South Asia under Changing and Variable Climate: A case study from Sri Lanka"

Dr. Buddhi Marambe: University of Peradeniya (Sri Lanka)

Chair : Toshinori Nagaoka --- Page 6

14:30 Coffee break

Reports of studies supported by the 2013 Grant-in-Aid for Research from the Graduate School of Biosphere Science 2013

14:50 "Preparation of germinated paddy with high gamma- aminobutyric acid by soaking combined with anaerobic and fluidized bed heat treatment"

GABA

Dr. Ratiya Thuwapanichayanan: Kasetsart University (Thailand)

Chair : Akihiro Ueda --- Page 11

15:30 "Paralytic Shellfish Poison (PSP) –The Safety of Food from the Sea"

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Dr. Manabu Asakawa: Hiroshima University (Japan)

Chair : Tadashi Shimamoto --- Page 13

16:10 General Discussion Chair : Hiroshi Sakugawa

16:25 Closing Remarks Kazuya Nagasawa, Vice Dean

■ **Reports of studies supported by the 2013 Grant-in-Aid for Research from the Graduate School of Biosphere Science, Hiroshima University**

2013

Environment of Food Security and Food Safety in Vietnam

Phan Tai Huan* and Le Thi Kieu Thu

Faculty of Food Science and Technology, Nong Lam University – Ho Chi Minh City, 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

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

Buddhi Marambe
Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka

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].

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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

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

Ratiya Thuwapanichayanan*
Department of Farm Mechanics, Faculty of Agriculture,

(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

Manabu Asakawa*
Department of Biofunctional Science and Technology,
Food Science and Biofunctions Division,
Graduate School of Biosphere Science, Hiroshima University

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

* Associate Professor, Department of Biofunctional Science and Technology, Hiroshima University

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 mosswo s25(Duri)-5.1(ng the sreenin)2surveilla(s

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

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Reports of studies supported by Grant-in-Aid for Research from the Graduate School of Biosphere Science, Hiroshima University

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“Polymorphism Associated with Stress-Related Behavior in Chickens”

Takashi BUNGO (Graduate School of Biosphere Science)

831 833
20-30
(TI)
15
5 15
(MR) :

DNA PCR
RFFP GHSR
c.739+726 T>C
Kruskal-Wallis Steel-Dwass

TI 831 30 1.1 ± 0.1 833 27 1.3 ± 0.1 22 1.5 ± 0.2
20 1.1 ± 0.1 P=0.059
831 150 ± 38 833 55 ± 14 82 ± 14 240 ± 41
831 833
P<0.001
MR 831 151 ± 18 833 119 ± 19 147 ± 20 175
± 21 P=0.167 831 3.5 ± 0.6 833 4.1 ± 0.7
2.5 ± 0.4 7.1 ± 1.0 P<0.001
42.6% 29.4%
72.0% 0.922 -0.923
MR 0.746
-0.782 TI

GHSR TT 73.68% TC
25.33% CC 0.06% T 0.863 C 0.127
GHSR
P<0.05

TI MR
GHSR C