PRESPECTIVE OF WASTE UTILIZATION IN SEAFOOD INDUSTRY

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Abstract- There are large amount of organic waste from processed seafood processing in terms of wastewater and solid waste. This study investigated waste utilization of frozen seafood industry in order to determine preferable technologies for waste management of seafood industries in Thailand. Fish waste is a rich source of essential amino acids and others. Frozen fish processing activities generate potentially large quantities of organic waste and by-products from inedible fish parts. Thus all inedible fish waste should be utilized rather than disposal. Mixed processing fish waste of about 1 kg was collected from rejected conveyer. The fish waste composition was categorized from 4 fish strains: Threadfin Bream, Purple-spotted bigeye, Croaker, and Siamese glassfish. The waste generation depends on the species and the process. Fish waste obtained in this study consists of head and gut, bone and meat scrap, blood, and whole size-rejected fish (75%, 16%, 6%, and 3%, respectively). The majority of fish waste was head and gut (75%) obtained from the frozen surimi production. The most captured species are ground fish and it is estimated that only 25-50% of the raw material is utilized for primary products. The remaining 50-75% of the raw material is considered processing waste and is disposed or utilized for low-valued products such as animal feed in livestock for cattle. Typically, most of fish waste is transferred asby-product material to fish meal industry. Therefore, value added alternatives would be suggested for fish waste management. Biogas production under anaerobic condition and composting by aeration are recommended. However, the utilization of seafood processing waste required efficiency improvement according to its inadequate biological stability, potentially pathogenic nature, high water content, potential for rapid auto oxidation and high level of enzymatic activities.

Keywords- Anaerobic Digestion, Composting, Seafood industry, Seafood wastewater, Seafood industrial waste, Waste utilization

I. INTRODUCTION

Importance of seafood waste recovery

Food is an important for humans. To access nutritious foods of animal origin is crucial in the development of early human brain and hominids. Seafood as fish, crustaceans, and shellfish are a source of protein and healthy fats is an important role in nutrition for civilizations (Nikoo and Benjakul 2015). Aquatic animals contain essential nutrients, such as iodine and omega-3 long-chain polyunsaturated fatty acids (LCPUFAs) that are generally limited in other animal foods(Gormaz, Fry et al. 2014). A consumption of seafood has been increase by apopulation growth and interests of consumers lead to the industry for privatization and preservation in order to have a comfortable providence. Consumers are becoming more sophisticated, with increasing awareness of hygiene and safety, and expectations of better nutrition and more convenience (Suwannaporn and Speece 1998). The processed seafood factories recompense for demand of products. Most of seafood product is consumed fresh (almost 56%), while 14% is consumed as canned seafood and 30% is sold as frozen or boiled products (Vázquez-Rowe, Villanueva-Rey et al. 2013). However waste from processed seafood processing have occurred in term of wastewater and solid waste. Processing waste from factories may cause to badly hygiene of employee and encircling community. Waste reduction to zero-waste is essential for environment friendly and human health (Love, Fry et al. 2015).

The aims of this paper were studies waste utilization of seafood industry in order to determine preferable technologies for waste management of seafood industries in Thailand.

Alternatives for seafood solid waste management

Fish waste is a rich source of essential amino acids and others. Thus all inedible fish waste should be utilized rather than disposed. Options for using fish wastes are listed below (C. Visvanathan, 2007);

1. Extract biochemical and other pharmaceuticals
2. Extract color additives
3. Produce gelatin from skin and bones
4. Use solid waste in fishmeal and oil production
5. Use solid waste in silage production
6. Use solid waste in compost production
7. Use solid waste directly as fertilizer
8. Use solid waste for fish bait or chum
9. Use solid waste for animal feed

For instance, A New Zealand fish processor decided to look for an alternative to landfill for disposal of its fish wastes. After considerable research, the company installed a fish bio- digester. Using anaerobic digestion, the plant now produces two useful by-products: methane and fertilizer. Methane (biogas) is used to heat the digester and to supplement the energy requirements of the plant. Sales of the by-products of what previously was waste are US$9000 per month. Energy savings Seafood Processing Term Project 2 21 amount to US$4000 per year and annual disposal charges of US$12,500 have been saved. The overall payback period is estimated at 6 years. (UNEP Report, 1999)

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II. DETAILS EXPERIMENTAL

2.1. Materials and Procedures

Material and waste monitoring

A specific frozen seafood manufacturing

This paper extends the analysis of a case study that examined seafood waste utilization project in Thailand. Company C, located in the southern region of Thailand approximately 950 kilometers from Bangkok, was selected as a key case. The integrated wasteutilization focuses on solid waste management using 1 kg mixed processing fish waste from 4 fish strains: Threadfin Bream, Purple-spotted bigeye, Croaker, and Siamese glassfish Basically, the processing of frozen surimiproduces large amount of fish waste, which is used as animal feed in livestockfor castle. The project activity also involves the capacity expansion of the existing waste utilization located next to the surimi production plant. Additional site visit and face-to-face interviews were also performed.

III. RESULTS AND DISCUSSION

3.1. Seafood processing in Thailand

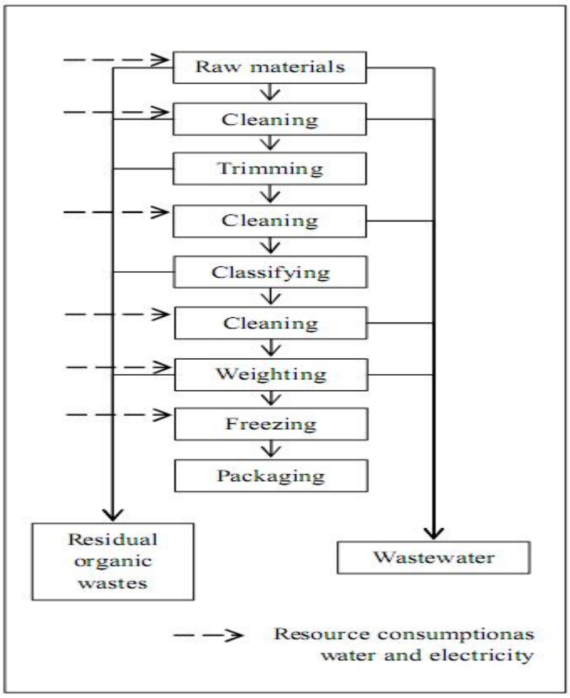

Fig 1Water and electricity consumption in frozen seafood production (modified from Sohgratok, 2013)

Aquaculture, on the contrary, supplied nations with over 55 million tons of fish, 32% more than in 2004, constituting, therefore, the fastest-growing animal-food producing sector (Vázquez-Rowe, Hospido et al. 2012). Thailand is the world's seventh largest seafood producer, which produced 1,233,877 tons of seafood per year, accounting for 1.9% of global seafood production (Nations 2014) so there is many seafood factories, especially the southern of Thailand area (Chevakidagarn, Wanaglad et al. 2012). The highest products of seafood are canned tuna and canned sardines, subordinate the frozen shrimp (Sohgratok 2013). The processed seafood industries of Thailand are two major categories of frozen seafood factory and processed (cooking-canning) seafood factory. Fig 1 and Fig 2 showed frozen seafood process and processed seafood process, respectively. Process of frozen seafood products use water in several processes for washing, cleaning and use electricity for manufacturing operation similar to processed seafood process. Procedure of cooking seafood product consist of precooking, cooling, cleaning, flaking, cutting, can filling, sterilization and packaging including water steam for fervor process.

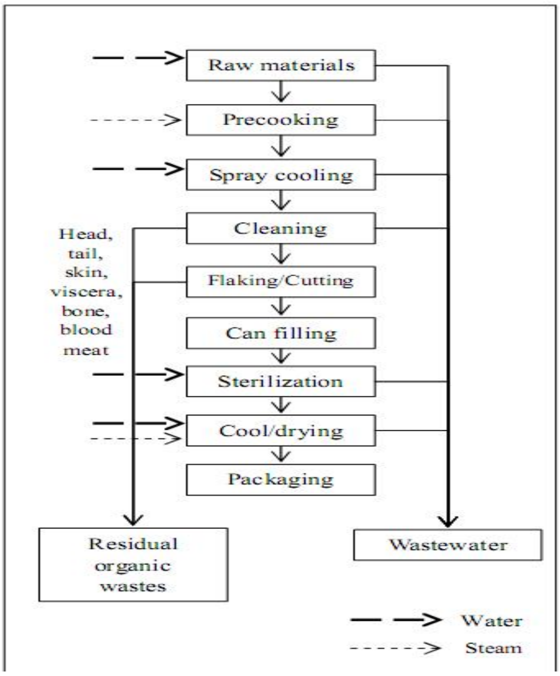

Fig.2 Process flow diagram of pre-cooked seafood products (modified from Uttamangkabovorn, Prasertsan et al. 2005)

3.2 Waste from Processed Seafood Manufacturing

3.2.1 Wastewater

The common environmental problems of the processed seafood wastewater in Thailand are high water consumption and high organic matter content in wastewater. Water consumption in processing is 13.0 m^3/ton of raw material. The major sources of wastewater are spray cooling process (4.7 m^3/ton) and equipment and floor washing (4.5 m^3/ton). The biggest pollution source in wastewater is from precooking, which has the COD, oil and grease, TS and SS of 66,222, 1,727, 57,192 and 7,000 mg/L, respectively. The combined wastewater has the COD, oil and grease, TS and SS of 3,248, 216, 3,799 and 742 mg/L, respectively. (Uttamangkabovorn, Prasertsan et al. 2005). The combined wastewater of frozen seafood has the pH, COD, BOD, TKN, TP, SS and oil and grease of 6.73-7.17, 1,460-3,097 mg/L, 1,369-2,239 mg/L, 157-303 mg/L, 1.79-2.82 mg/L, 104-1,267 mg/ and 76.3-146.3 mg/L, respectively (Kaosol and Sohgrathok 2013).

3.2.2 Organic solid waste residues

Waste in the seafood industry is characterized by a high ratio of product specific waste not only does this mean that the generation of this waste is unavoidable, but also that the amount and kind of waste product which consists primarily of the organic residue of processed raw materials, can scarcely be altered if the quality of the finished product is to remain consistent. The seafood processing wastes mainly consist of organ, head, tail, skin, viscera, bone, blood meat and unselected size. The characteristics of fish waste showed that high source of minerals, 58% protein, 19% fat, detection of toxic substances (As, Pb, Hg and Cd) at non-problematic concentrations, decrease of waste digestibility with temperature (Jayathilakan, Sultana et al. 2012). The composition of fish waste was analyzed as presented in Table 1.

Table 1 Composition of fish waste from surimi process

Component	Percentage (%)
Head and Gut	75
Bone and Meat scrap	16
Blood	6
Whole size-rejected fish	3
Total	**100**

3.3. Waste utilization technologies

The utilization of seafood processing waste required efficiency improvement according to its inadequate biological stability, potentially pathogenic nature, high water content, potential for rapid auto oxidation and high level of enzymatic activity. These is technology for utilize wastes to valued using

3.3.1 Biogas

The anaerobic digestion of biomass feedstock or the organic waste from factory is widely recognized as a mature and cost-effective process for producing biogas, which is a valuable renewable primary-energy source. Increasing interests in renewable energy production and in reduction of the greenhouse gas emissions associated with fossil fuels has made anaerobic digestion of plant biomass an attractive option. Biogas can be categorized as one solution for this renewable energy promotion scheme as well as an alternative for reduction of greenhouse gases emissions (Kaosol and Sohgrathok 2013). Biogas, a clean and renewable from of energy can be a good substitution of conventional sources of energy (fossil fuels, oil) which are causing ecological environmental problems and at the same time depleting at a faster rate. Biogas is the Biogas is the combustible gas produced through an anaerobic digestion at low-temperature and without oxygen. Thus, its application includes electricity, heating and cooking (Lerdrattranataywee and Kaosol 2015)

3.3.2 Composting

The composting is one of best alternative method for waste management, which allows their reuse as soil conditioners or organic fertilizers at agricultural land for food and feed crops without toxic effects(Villasenor, Rodriguez et al. 2011)(Awasthi, Pandey et al. 2016). Aerobic composting is decomposed by aerobic microorganisms under the optimum conditions of C/N ratio, moisture content and oxygen content. Especially, the optimum C/N ratio can fasten than the degradation rate of composting. The optimum C/N ratio of the composting material is range 25-35. The suitable moisture content is between 50-70%. The oxygen content is one of importance factor for aerobic composting. Additional oxygen increases the composting efficiency. The oxygen can be added by mechanical aeration, air blower, forced aeration and passive aeration (Lerdrattranataywee 2014).

CONCLUSIONS

There are large amount of organicwaste from processed seafood processing in terms of wastewater and solid waste. Processing waste from factories may cause to badly hygiene of employee and encircling community. Waste reduction to zero-waste is crucial for sustainable environment.

The selected seafood manufacturing applied integrated waste utilization focuses on solid waste management. Mixed processing fish waste of about 1 kg was collected from rejected conveyer. The fish waste composition was categorized from 4 fish strains: Threadfin Bream, Purple-spotted bigeye, Croaker, and Siamese glassfish. The component of fish waste was examined in terms of head and gut, bone and meat scrap, blood, and whole size-rejected fish equal to 75%, 16%, 6%, and 3%, respectively. The majority of fish waste was head and gut (75%) obtainedfrom the frozen surimi production.

It is estimated that most of waste material is utilized for animal feed in livestock for cattle.Therefore, value added alternatives would be suggested for fish waste management. Biogas production under anaerobic condition and composting by aeration are recommended.

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REFERENCES

[1]. Awasthi, M. K., A. K. Pandey, et al. (2016). "Co-composting of gelatin industry sludge combined with organic fraction of municipal solid waste and poultry waste employing zeolite mixed with enriched nitrifying bacterial consortium." Bioresource technology.

[2]. Chevakidagarn, P., O. Wanaglad, et al. (2012). "Optimum Carbon/Nitrogen Ratio for upgrading single-stage activated sludge process in the Frozen Seafood Industry." Thammasat International Journal of Science and Technology17(4): 11-21.

[3]. Gormaz, J. G., J. P. Fry, et al. (2014). "Public Health Perspectives on Aquaculture." Current Environmental Health Reports1(3): 227-238.

[4]. Jayathilakan, K., K. Sultana, et al. (2012). "Utilization of byproducts and waste materials from meat, poultry and fish processing industries: a review." Journal of Food Science and Technology49(3): 278-293.

[5]. Kaosol, T. and N. Sohgrathok (2013). "Enhancement of Biogas Production Potential for Anaerobic Co-digestion of Wastewater Using Decanter Cake"American Journal of Agricultural and Biological Sciences8(1): 67.

[6]. Lerdrattranataywee, T. K. a. W. (2014). Temple Waste Utilization for Aerobic Co-composting. 3rd International Conference on Environmental Engineering, Science and Management, Bangkok, Thailand, Environmental Engineering Association of Thailand.

[7]. Lerdrattranataywee, W. and T. Kaosol (2015). "Effect of Mixing Time on Anaerobic Co-digestion of Palm Oil Mill Waste and Block Rubber Wastewater." Energy Procedia79: 327-334.

[8]. Love, D. C., J. P. Fry, et al. (2015). "Wasted seafood in the United States: Quantifying loss from production to consumption and moving toward solutions." Global Environmental Change35: 116-124.

[9]. Nations, F. a. A. O. o. t. U. (2014). FAO global aquaculture production volume and value statistics database updated to 2012. F. a. A. Department;.

[10]. Nikoo, M. and S. Benjakul (2015). "Potential application of seafood-derived peptides as bifunctional ingredients, antioxidant–cryoprotectant: A review." Journal of Functional Foods19, Part A: 753-764.

[11]. Sohgratok, N. (2013). Biogas Production from Decanter Cake of Palm Oil Mill with Wastewater from Frozen Seafood Inductry. Master of Environmental Engineering, Prince of Songkla University.

[12]. Suwannaporn, P. and M. Speece (1998). "Organization of new product development in Thailand' food processing industry." The International Food and Agribusiness Management Review1(2): 195-226.

[13]. UNEP. (1999). "Industrial Sector Guide. Cleaner Production Assessment in Fish Processing Industry". Danish Environmental Protection Agency in cooperation with COWI Consulting Engineering and Planners AS.

[14]. Uttamangkabovorn, M., P. Prasertsan, et al. (2005). "Water conservation in canned tuna (pet food) plant in Thailand." Journal of Cleaner Production13(6): 547-555.

[15]. Vázquez-Rowe, I., Hospido, A. (2012). "Best practices in life cycle assessment implementation in fisheries. Improving and broadening environmental assessment for seafood production systems." Trends in Food Science & Technology28(2): 116-131.

[16]. Vázquez-Rowe, I., P. Villanueva-Rey, et al. (2013). "Carbon footprint of a multi-ingredient seafood product from a business-to-business perspective." Journal of Cleaner Production44: 200-210.

[17]. Villasenor, J., L. Rodriguez, et al. (2011). "Composting domestic sewage sludge with natural zeolites in a rotary drum reactor." Bioresource technology102(2): 1447-1454.

[18]. Visvanathan, C. (2007). “Seafood Processing”. Term project in ED78.20 Industrial Waste Abatement and Management. Available online at http://www.fpeac.org/seafood/IndustrialWasteAbatement-Seafood.pdf

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