FISH BONE WASTE UTILIZATION PROGRAM FOR HYDROXYAPATITE PRODUCT: A CASE STUDY OF KNOWLEDGE TRANSFER FROM A UNIVERSITY TO COASTAL COMMUNITIES

Mamat Ibrahim Bin*, Aisyah Dara¹, Sontang M.², Rosufila Zuha³ and Ahmad Nina Marlin⁴

1. Center for Socioeconomic Research, Universiti Malaysia Terengganu (MALAYSIA)
2. Faculty of Science and Technology, Universiti Malaysia Terengganu (MALAYSIA)
3. Faculty of Management and Economics, Universiti Malaysia Terengganu (MALAYSIA)
4. Faculty of Social Development, Universiti Malaysia Terengganu (MALAYSIA)

Received August 13, 2012

ABSTRACT

Fish bone waste has long been used in research laboratories and it is unfortunate that still many communities fail to understand its importance that makes it necessary for the program to transfer knowledge to the community in order to improve its usefulness. The technology of processing fish bone that has been transferred to the community was to utilize the fish bone waste into the various needs of the community. The program is seen as having the capability to improve the community environment and contribute to community development policy, projects and research in social engineering. Fish bone is a form of waste generated from the fish crackers processing industries that contain the highest content of calcium. In terms of food and nutrition, fish bones are rich in calcium, phosphorus and carbonate needed by human. Involvement of the community to use leftover fish bone to produce hydroxyapatite is a way to improve society and reduce pollution. In addition, hydroxyapatite can also be used as a bone replacement implants, heart valves, hip extension and other implants in the human body.

Key Words: Technology transfer, Fish bone waste, Hydroxyapatite, Development of coastal community, Crackers processor

INTRODUCTION

This study is one of the programs of social engineering research group at the Universiti Malaysia Terengganu, Malaysia focus on crackers processors in Mengabang Telipot, Kuala Terengganu. This study aims to use leftover fish bones into various products for community needs. This program is expected to create effective cracker processors community that can be recognized as an environmental friendly in rural areas. The assessment and rating of clean products in the processing industry should follow the guidelines published by the United Nations Environment Programme (UNEP), Division of Technology, Industry and Economics (DTIE), Danish Environmental Protection Agency. This clear guideline is essential in producing clean productions of fish crackers, focusing on fish waste. The goal is to raise awareness about the benefits of fish waste (i.e fish bone) and its impact on coastal community. Collaboration among universities, community, industry and government agencies needs to be implemented to achieve an effective program and tackling the environmental issues. Marine fish account for 90% of fish resource haul and the rest is from freshwater fish and fish farming. Fish processed into chips, fillets, canned food, protein products, fish and fish oils. 75% of fish stock are used for human consumption and 25% used for fish oils. Processed fish for human consumption is only 30% of the market. Recently the demand for fresh frozen fillet has increased. Fresh fish products are highly perishable and refrigerated storage is required for life to maintain and prevent damage to the

*Author for correspondence
product. Conversely, the processed fish such as canned fish, fish meal and fish oil which has a longer life expectancy, requires refrigeration. Processing ends with the disposal or recycling of waste product. Fish processing is a major contributor to the overall environmental problem especially waste organic odor problem. Various efforts have been undertaken to address the problem of waste disposal including the production of fish sauce, protein concentrates and hydrolysates protein. In addition, gelatin has been cultivated from the skin and bones and as ingredients to enhance the elastic properties, consistency and stability of food products. The production of gelatin from fish skin and bones not only aims to exploit the ancillary materials but also as an alternative to gelatin from animals although gelatin from animals is better since it has high dilution level and acetylation. In addition to food products, they also produce handbags, purse, briefcase, watch strap and belt from fish skin. Fish bone waste in the form of hydroxyapatite provide value added to fish cracker processor, since it can be used to reduce environmental problem. It also can be used as implant materials in bone replacement (bone substitution), heart valves, hip extension and other implants in the human body and human teeth due to the same characteristics of human bones and teeth in terms of chemical structure. There is an increase of hydroxyapatite as a bone substitute material for patients with osteoporosis and a high accident rate. At the same time, the need of fish is also very high in the diet causing a high increase of fish bone waste.

Seafood processing is a major industrial in Kuala Terengganu, Malaysia. Processing of waste such as intestine, fish bones and fish skin originating from fish cracker factory in a community has become an issue of environmental pollution. Therefore, this paper can provide an important contribution to community in overcoming the adverse effects of the environment, to create the relevant policies and strategies on environmental waste management inorder to achieve sustainable community development.

**Definition of knowledge transfer**

Knowledge workers such as experts, researchers and lecturers have conducted various studies to transfer knowledge to all stakeholders. In reality, the researches are focusing on the benefits of their research while the practitioners want to know how this knowledge is useful to them. Similarly public organization wants to know how profitable is the research findings and universities tend to focus on the recognition of the research. Therefore, a committee needs to be established, reviews to be carried out, writings should be published in order for the knowledge transfer program to be successful. The definition of knowledge transfer is the process or result of moving knowledge from one point to another.

Knowledge is new information to a person or organization which research outcomes, prevention guidelines, the manufacturing process, work methods and innovation. Knowledge comes from perception or from experience gained in the state and the various ways that are stored in memory. Knowledge includes from the most concrete to the most abstract – objects and facts. Category of objects or facts, is characterized by the features and relations, ideas, perceptions and concepts that help to define or create a category that is easy to understand. There are three main categories of knowledge. Knowledge of declaration which is the objects associated with knowledge (i.e. concepts, law, rules, facts, etc); knowledge of procedural which is related to the way in which knowledge is used and conditional knowledge that simplifies the application procedure declaration and knowledge in different contexts. The concept of transfer is a structured process that uses scientific research findings to improve the professional practices. It is understood as a process of continuous change punctuated by two-way exchange between the two communities of researchers and potential users. Transfer process in education is a process to construct new knowledge or develop new skills, or to perform new tasks. Meanwhile, the concept of transfer is defined as the mechanism for disseminating, and using new knowledge for new individuals to practice the behavior of the organization. Subsequently, transfer in the humanities and social science is a systematic way to obtain,
collect and share knowledge and convert it into a practical knowledge. Therefore, the transfer of knowledge is a process that facilitates individual or organization to access important information that is identified not only for one person but also a diverse group. This knowledge transfer is regarded as a social process. The majority of this definition reflects the transfer as a process, the mechanism of scientific knowledge developed by researchers to be available to consumers. Knowledge is seen as a product, with an expectation of transformation, i.e the translation into the language to be understood as well as the availability of tools that can be used in all situations and in decision making of various purposes, in changing the behavior of individuals or organizations, in developing policies or programs, as well as in problems solving processes.

This program brings researchers who are deeply interested in issues related to knowledge transfer in getting a lot of experience, understanding, and "know-how". It is reasonable to think that in the years to come, researchers will not only become increasingly interested in these issues but they will also try to form conceptual modeling to communities.

Utilization of fish bone for hydroxyapatite

There is a need to introduce the utilization of fish bone to produce hydroxyapatite (Hydroxyapatite / HA), and used it as materials to reduce heavy metal contamination which is still unknown to the fish chips processor community. In addition to developing fisheries and oceanography, the utilization of fish bones is also an alternative to address contamination problem. Hydroxyapatite has currently been used in several areas, such as medical, health, food (gelatin), and overcomes contamination. Fish bone for hydroxyapatite is readily available on the east coast of Peninsular Malaysia.

Case of overcoming contamination by coastal community through delivering knowledge on utilization of fish bone as materials to reduce metal waste is important. The program’s target groups are fishermen who are fish processors in Mengabang, Telipot Kuala Terengganu. Fish processor community has a large potential that can be developed to maximize the economic well being of the community. The utilization of increased fish bone waste still needs to be looked into. This not only adds value to the fish processing business, but also can overcome the environmental problems, especially the bad odor and dirty environment. The majority of waste generated by fish processing factory comes from the head, bone, fish skin and tail. Fish bone contains calcium phosphate, phosphorus, and carbonate. These unused wastes remains as waste disposal that disturbs the environment especially the unpleasant smell and water pollution that contains Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Suspended Solids (TSS). Through appropriate technology, potentially this waste can be processed further into a ceramic compound in which includes Hydroxyapatite Ca$_{10}$(PO$_4$)$_6$(OH)$_2$. This product does not decomposed easily and does not have toxic properties that are dangerous to the environment. Hydroxyapatite has a very high economic value. The results show that Hydroxyapatite is able to remove heavy metals in overcoming environmental pollution. Hydroxyapatite is a ceramic material, which is effective in removing heavy metals given that Hydroxyapatite has polikation which inhibits bacterial growth.

Based on the above background, it is apparent that there are problems of how to introduce the use of fish bone to the community, ways of motivating the community to gather fish bone, how to chemically process fish bones into hydroxyapatite and how to use hydroxyapatite to benefit coastal communities, particularly in Kuala Terengganu. This program aims to introduce the hydroxyapatite to the community in order to take advantage of fish bone wastes making them more useful as hydroxyapatite with simple manufacturing methods and without the expensive and sophisticated equipment; to identify ways of motivating the community to collect and utilize the hydroxyapatite as an alternative to discard heavy metals in tackling pollution. It is expected that through this program the coastal community can grasp the skills and expertise in developing knowledge and technology to process the fish bone into hydroxyapatite.
Knowledge transfer model and waste utilization

Fish bone waste is part of organic waste that is unused either in fish trade sector or for human consumption. In other words, there is no demand for fish bone waste. In Malaysia, management of organic waste such as fish bone is the focus point to achieve environmental sustainability. The studies on waste management and the problems encountered and plans for the implementation of a systematic management had been conducted by European and American researchers, namely the study by Reschovsky & Stone in New York, Anderson in Denmark, Bauld & Hickman in Nova Scotia, Isaacs, in Canada and Ishizuka, Hijasima and Macer (in Taiwan). Further studies concerning the integrated waste management approach based on the waste hierarchy approach which includes optimization of waste at source, recycling, composting, landfills and incinerators have been carried out by Western researchers such as Brummer & Ernst, Habitat II, Cooper, Cooper, and Arner. Studies related to waste management problems at the local level have been done by the students and researchers. Related research and management problems are conducted by Azahariah in Alor Setar, Mohd.Zanuddin in Kota Bharu, Ee and Shaniza in Georgetown, Bavanee in Georgetown and Sharul Piaza in Klang. Research related to economic factors, social and audit has been done by Mohd. Nasir, Mohd. Nasir, Rakmi, Wan Nor Mohd. Kamil & James, Mohd. Nasir and Rakmi, Mohd.Nasir, Nurlaily, Rakmi, Saifulah, Mohd. Nasir, Zulna and Rakmi. It can be said that the findings of these studies have contributed towards organic waste management.

Industrial food waste is one source of the contaminated environment. The study was carried out in respect of the expansion method wastes into useful products. Based on various studies, there should be a collaboration between university and community, especially those concerned with the study of the implementation of knowledge transfer program on the utilization of fish bones in the form of organic waste for useful products. Training on knowledge transfer is defined as a planned learning that is designed to deliver knowledge to enhance the effectiveness and efficiency of each individual in the community to change behavior, knowledge and attitudes. The transfer of training refers to the use of knowledge, skills and behavior by the trainees that is influenced by the environment, support from a researcher, as well as from the technology. Conclusions can be made about the transfer of knowledge through training based on the definitions put forward by the experts as the application of knowledge, skills, behavior and practice in the utilization of fish bone waste into products. It is hoped that this knowledge transfer is able to create a sustainable environment and spur economic development in a community.

AIMS AND OBJECTIVES

This paper is an attempt to introduce environmental management tools through the utilization of processing waste, which has proven effective in terms of economic and environmental benefits. Waste utilization technology involves selection and processing of fish bones into a community product, requires fish cracker community involvement as the main source of sterilized fish bone samples. Hence, the implementation of knowledge transfer programs highlighted in this paper can be used effectively to manufacture products from waste processing factory in Mengabang Telipot Kuala Terengganu, Malaysia.

METHODOLOGY

Implementation of knowledge transfer model to fish crackers processor group

In implementing the program, the observation method is used to observe the activities of the fish crackers processors. The objectives of observation were to find out information on the potential waste of fish bone, fish bone sample preparation, and fish bone waste collection activities by the community. Cooperation from the Head of the Village (Ketua kampung) is needed to smoothen the knowledge transfer to the community. Preparation for the
implementation of the program included a written review of the transfer model, the target groups’ collection activities, the preparation of samples and equipment inorder to determine the right strategy in the making of hydroxyapatite. Next is to show hydroxyapatite samples to target groups, as well as make video on how to manufacture hydroxyapatite. Implementation of the program is carried out for six weeks. The preparation of sample hydroxyapatite from the fish bone waste was explained using lecture, discussion, and demonstration. Overall the transfer knowledge program takes approximately two weeks of lecture, one week of outreach and evaluation activities and three weeks for writing the final report.

Field work
Field work were done thrice. First visit was conducted to interview the Head of the Village and coastal community. Interviews were done at night since most of the respondents were working during the day. This coastal community has a large potential to participate in the program due to the nature of their work and as main contributors of fish bone waste. The visit to meet the village head is important inorder to gain his coorporation for the success of the program.

Second field work was carried out to seek the corporation from the village’s head and understanding of the planned activities of the program. The third observation is to ensure the right activities are implemented for the program. It is hoped that through the observation, the village’s head would promote and provide necessary equipment (i.e chairs, lighting and sound system) for the program.

RESULTS AND DISCUSSION
Hydroxyapatite sample
Based on the research theories, the aim of preparation of sample is to help the community to understand how to manufacture hydroxyapatite. The physical sample is prepared in the lab of Science Physics Department, Faculty of Science and Technology, Universiti Malaysia Terengganu. Hydroxyapatite (HA) is produced by the combustion of the fish bones taken from the waste fish crackers processing center in Mengabang Telipot, Kuala Terengganu. HA production process includes cleaning and grinding of raw fish bone to powder. Powder is sifted into different sizes of 25 μm, 53 μm and 150 μm. This is followed by incineration with a different temperature from 900 °C to 1200 °C for 2 hours. The fish bone powder was examined using Fourier Transform Infra Red Spectrometer (FTIR), X-Ray Powder Diffraction (XRD) and Tabletop Microscope (TM).

Morphological analysis of hydroxyapatite with SEM (Scanning Electron Microscopy)
SEM can provide information about the microstructure of the surface sample and powder HA morphology. SEM analysis results show that solvent water forms clots. With an increasing temperature, the surface area gets smaller. This forms a smaller clots until lumps are formed indicating that the formation of smaller crystal is growing. The main pollutant in hydroxyapatite is carbonate which was identified from the FTIR results. Secondary phase in the formation of hydroxyapatite is Calcium Oxide which is a result of heat treatment on the thermal degradation of hydroxyapatite. From the data analysis, the optimum hydroxyapatite is obtained by using the characterization of X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), and Fourier Transform Infrared Spectroscopy (FTIR). Hydroxyapatite is crystal in nature and has high mechanical strength.

After all the testings done and comparison with the previous research, the findings show that the best HA fish bone is the one with particles sized of 25 μm which was burned at 1100°C for 2 hours.

Make a video on how to manufacture hydroxyapatite
In order to facilitate the transfer process, the video was shown to the public on how to manufacture hydroxyapatite. UMT made this video which shows the process of making hydroxyapatite from fish bone. The end result is a video on how to produce hydroxyapatite which is stored in CD form.

Implementation of the knowledge transfer program (Hydroxyapatite)
The implementation of knowledge transfer program of hydroxyapatite has two phases.
The first phase involves the explanation on methods of making hydroxyapatite from fish bone waste. The second phase is the use of hydroxyapatite as a way to overcome pollution. The Mengabang Telipot coastal communities were not well informed about hydroxyapatite. Therefore, a session to introduce the product is needed. The session begins with an introduction on hydroxyapatite followed by a video presentation showing on how to produce the material from fish bone waste which was previously made in the University’s lab.

After the screening of a video, an explanation on how to manufacture hydroxyapatite is presented by the researchers. The method of making hydroxyapatite is demonstrated to selected representatives from the community. The event ended with the sample distribution of hydroxyapatite to the participants so that they can use it to reduce pollution. The next activity is to demonstrate the main usage of hydroxyapatite as an agent for water purification. Participants in the program are expected to be more aware of the use of hydroxyapatite, especially measuring the right amount of hydroxyapatite to be placed in the water for purification. At the end of the program, there was a discussion among the representatives of the community of Fishermen's associations, fish traders and in particular fish crackers processors in the area to plan for an effective transfer program.

Finally, a mutual corporation is formalized among the representative of fishermen's and the wish bone processors, which was witnessed by the representatives from the Center for Socioeconomic Development, ECER, the LKIM (Malaysia Fisheries Development Board) and the Fisheries Department.

Outreach activity

The knowledge transfer program to the community in the form of outreach activity has been implemented to assist coastal communities in the making of hydroxyapatite from fish bone waste. Outreach activities was conducted two weeks after the initial program in Mengabang Telipot. This activity aims to help coastal communities in the manufacturing and using of hydroxyapatite through in-situ training. In this outreach activity, CSD serves as a facilitator to help people who have experienced difficulty in training. In addition, CSD works together with the ECER, LKIM, and the Fisheries Department to monitor target groups in manufacturing and using hydroxyapatite.

The hope is for the community to be aware, accept and use hydroxyapatite to increase their income. It is also hoped that other interested parties will also use hydroxyapatite. This is because the coastal community has limitations to manufacture hydroxyapatite as it requires laboratory equipment and tools that are beyond their means.

CONCLUSION

This program is very useful because it involves the management of organic waste and the use of fish bones for a variety of products to meet community needs. The program also reduces the environmental problems such as water pollution and metals in the water supply for the community. The benefits of this program to the community that they will get to know the value of hydroxyapatite, and knowledge of how to use hydroxyapatite to reduce pollution. Hydroxyapatite can be made from the fish bones through the washing process, deproteinised and demineralization. In the demineralization process, pounded fish bones are heated in a solution of 1 M HCl for 1 hr at 90 °C. After demineralization process, fish bones deproteinised, washed with distilled water until neutral. In the proteinization process, fish bones are washed and heated in a solution of 3.5 % NaOH at 90 °C for 1 hour. The final process, deacetylation is done by heating the fish bones that have been washed with the solution of NaOH 50 % at 120 °C for 1 hour. The use of hydroxyapatite to overcome the pollution is through soaking hydroxyapatite solution 1.5% for 10 minutes. Hydroxyapatite solution can be used several times.

From the activities listed in the program, it can be stated that:

Transfer of knowledge to the community about the use of hydroxyapatite considered as an alternative to overcome pollution problem.

The target group is encouraged to take advantage of fish bone waste and should enhance the skills in using hydroxyapatite. This is done through knowledge transfer.
program on the processing of hydroxyapatite. Knowledge transfer to the operators of fish crackers is done by using lectures, interviews and demonstrations. In addition, as a follow-up to this program, UMT will provide the hydroxyapatite, as well as outreach activities and cooperation with related parties. The results of outreach have shown that the community can process the fish bones into hydroxyapatite. The community is able to use hydroxyapatite to address the problem of water pollution.

REFERENCES
1. Sarabia et. al., Extraction and characterization of gelatin from different marine fish species in Malaysia, 10, (2000).


