DESIGN AND DEVELOPMENT OF SMALL-SCALE FISHMEAL PRODUCTION FROM FISH PROCESSING BY-PRODUCT

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Abstract - Fishmeal is the essential ingredient in the animal feedstuff. Itshigh quality can stimulate animals to take high growth and development of the animal meat quality.At present not only marine fish but also fresh water fish are used in making the fishmeal product so as to solve the problem of environment from the expansion of aquaculture industry.Fish by-product becomes more and more important used as the raw material for fishmeal production in the future. Farmers can earn an incomefrom feedstuff from their fish by-product or use it for their animal feed and help the well-being environment.Therefore, the development of a small-scale of fishmeal production is investigated.The purpose is the expected outcome of conceptual design of the fishmeal production unit. The research methodology is known as the simplified wet processing, conducted with modification of bone removing and defatting during cooking process. Two cooking typesare compared; name the boiling with stirring and the boiling with pressure. The results show that the boiling with pressure isbetter than the boiling with stirring cooking process, especially getting a higher yield and lower energy consumption. The pressure simplified processing can produce fishmeal at a third grade of the commercial fishmeal which is obtained above 30% of protein, lower 6% fat content and below 10% of calcium.

Keywords – Feed stuff, Fishmeal production, Fish by-product

I. INTRODUCTION

Fishmeal is the important ingredient in making feedstuff. High quality of the feedstuff can take high growth and development of animal meat.[1] The one third of world production of fishmeal was obtained from fish by-products in 2012. The fish by-product mean not only marine fish by-product but also fresh water fish by-product which become more and more important used as the raw materials for the fishmeal production in the future.

Fresh water fish such as Catfish (clariasgariepinus x clariasmacrocephalus.), Nile Tilapia (Oreochromisniloticus.) are widely cultured in Thailand since 2012. [2] [3]Thai farmers use the commercial feed which is a very high cost and extremely affects to their income. To solve this matter, sustainable aquaculture and sufficient economy has been introduced. One of the solutions is transforming fish by-product to be the fishmeal. Fish by-product comes from dried Catfish processing plant and Tilapia fillet processing plant which are fish processing waste i.e. head, gut and bone. They can be transformed to be used as the fishmeal and then formulated with other ingredients to be feedstuff or aquatic feed.[1] Then in this study the processing waste focuses on fishmeal processing in order to add its value and may develop animal feeds in the future. The researcher considers that the fishmeal process for sustainable agriculture principle should be designed in a simple process, cheaper, available equipment and low energy requirement.

II. MATERIALS AND METHOD

A. Fish processing by-product

Fish processing inevitably results in the generation of by-products.They are the raw materials such as heads, viscera, frames, skins and others likes tails, fins, scales, mince, blood, etc.These materials are not used in the primary product. The following fig. 1 shows half of tuna processing by-products which are similar to the fresh water fish processing yield in range of 30-50% of the fish. [4] [5] [6]

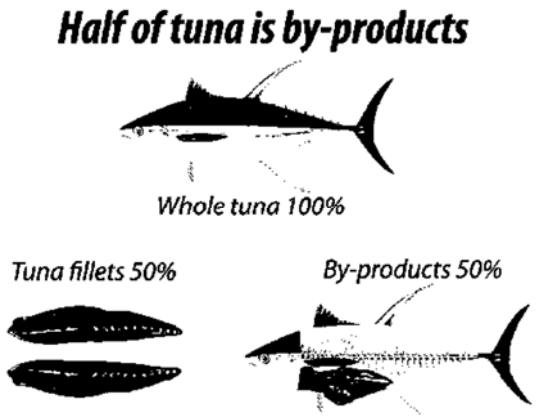


Fig.1 Primary and by-products of the tuna fish processing sector (from: www.spc.int)

B. Fishmeal production

Fishmeal processing is carried out in six steps: cooking, pressing, separating, evaporating, drying and grinding as shown in figure 2. Three outputs of this process are fishmeal, fish oil and protein syrup.[6]

The above flow process diagram shows the industrial fishmeal processing which is commonly used in marine by-products; especially Tuna processing waste that contains valuable fish oil and protein extract, however, freshwater fish contains different fish oil which may use for other purposes.

From the previous research[7], the Catfish Processing Waste (CPW) was processed in 5-step methods to

produce a fishmeal. It was cooked, squeezed, chopped, dried and grinded. The processed fishmealgained30% of high fat content, 15% of high calciumcontent and mixed with a hard skull. To make the fishmeal better, high fat content, and high calciumcontent should be reduced. Then in this study the head of catfish, which is the biggest part of the whole fish, should be chopped and squeezed before drying or removed after drying.
The design fishmeal processing in this studyconsists of 5 processes.It starts from cooking, after that squashing water with oil from cooked waste. Then the cake is milled into small pellets before drying and finally grinding the dried CPW cake.

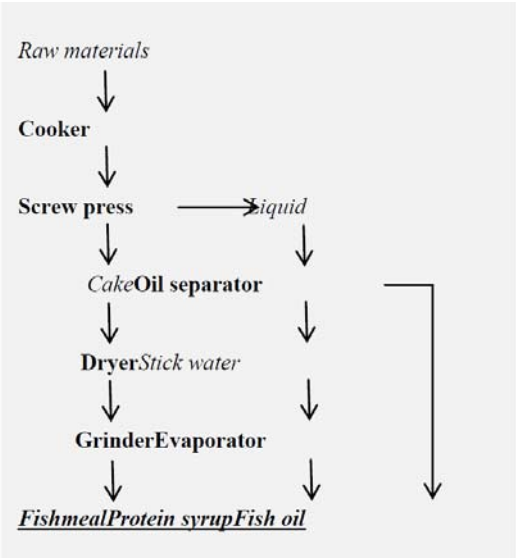


Fig.2The fishmeal Processing Flow Diagram (ZhoushanXinzhou Fishmeal Equipment Factory)

1. Cooking process

The cooking process is the first step to stop enzyme and microorganism in the waste not to deteriorate and spoilage. Normally boiling with stirring and boiling with pressure are used for cooking process in this study. To produce fishmeal from the aquatic processing waste should consider the pathogen transfer which may cause disease problem or contamination.[8] [9]So the cooking process of the fish by-productneeds to heat at 100^{o}C for 30 minutes or more.The boiling process, exceed water needed for this experiment is 2 times for both boiling with stirring processand boiling with pressureprocessare selected instead of steaming process. The fish by-products and water are boiled for 60 minutes with occasional stirring in boiling with stirring process. The pressure cooker is used for boiling with pressure process which is the fish by-products are boiled without stirring for 30 minutes.After that fish by-products is screened and washed by hot water in order to remove the existing oil from the fish by-products, and then cooled down before squeezing and milling.

2. Squeezing process

The manual compressing equipment, which is a simple squeezing process, is used as shown in figure 3. Cooked fish processing by-products is filled in the perforated column and then turn the handle clockwise to move the compression plate downward in order to compress the fish processing by-products and release the water with oil out of the perforated column.



Fig. 3 the manual compressing equipment

3. Milling process

The meat grinding equipment is used for cutting the fish processing by-products into small particles as shown in figure 4. Squeezed fish processing by-products is fed into a feed tube of equipment continuously and screw inside the grinder in order to pull fish processing by-products in and push towards a knight and the holes plate which fish processing by-products will be cut into small pieces. However, they are as a wet cake which have to be dried later.



Fig. 4 the Milling equipment

4. Drying process

Two techniques are used in this experiment; the Sun drying is applied in order to save power input and a tray dryer which controls drying temperature at 60^{o}C.

C. Experimental design

Design and development of a small-scale fishmeal production using the fish processing by-products

which is Tilapia fillet and dried Catfish process are investigated. The 5-processes of cooking, squeezing, milling, drying and grinding are used in this study and compared the cooking process under pressure and non-pressurized process as shown in figure 5.The fishmeal products from both processes will be evaluated and statisticallyanalyzed.

D. Conceptual design

This fishmeal production design in this studyaims to serve group of aquaculture Thai farmers forself-sufficient project and under friendly environment. The simple design of fishmeal production consists of 5 processes: start from cooking, after that squashing water with oil from cooked waste. Then the cake is milled into small pellets before drying and finally grinding the dried fish by-productcake.
Draining the boiling water and washing the cooked fish processing by-product by hot water and simultaneously remove big bones or skull before squeezing can reduce high fat content and calcium content in fishmeal from fish processing by-products.

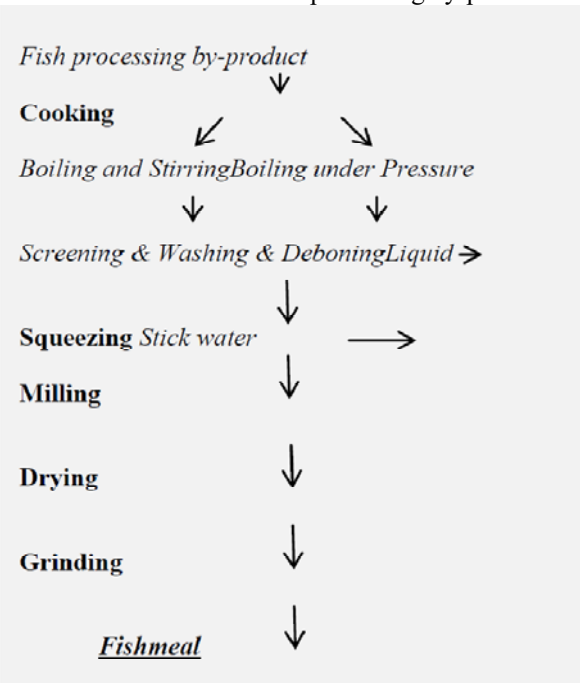


Fig.5The experimental design diagram

III. RESULTS AND DISCUSSION

A) Fishmeal Processing Design

The small-scale fishmeal production design for farmers and community entrepreneur can be a simple process such as normal boiling processing. Fish processing by-productsis cooked or sterilized before milling or drying. Unfortunately, the fish processing by-products from both catfish and tilapia processing contains a lot of oil accompanied with water during boiling. It should be squashed the oil and water out before milling and drying. To insure that oil is removed as much as possible, hot water is used for washing the fish processing by-production and deboning also simultaneously.

Results of cooking process between boiling with stirring process and boiling with pressure process show little difference in loosing solid, and both help to separate a bone easily. It seemsthat stirring action and pressurizing action during boiling affectthe same result but difference in power consumption. That is the boiling with stirring cost double compared tothe boiling with pressure.

Cooked fish processing by-production are squashed by the manual compressing equipment which is a simple method to squash water and oil out the cooked fish processing by-production.

Compressed fish processing by-production may be called a half dried fish processing by-production. It is nearly 30% of moisture removal including fish oil. However, this manual compressing equipment needs a man power which is hard to control force steadily and remaining liquid which is a combination of water and oil. Oil content will affect to its quality and power consumption of drying process. In this study,the cooked fish processing by-productionare washed by hot water after cooking. This is done with an expectation to reduce oil content.

The fish processing by-production then is milled by meat grinding equipment which is used for cutting the fish processing by-products into small particles, but they are still a wet cake which have to be dried as shown in figure 6.



Fig. 6 Milled fish processing by-product

Drying of fish processing by-production under control drying temperature at 60^{o}C can be sure that heat will not affect to protein content and other vitamins. So both Sun drying and tray drying at low temperature are the same in term of quality but only drying time and power consumption are different. Tray dry took 18 hours to dry the fish processing by-production to 9%MC compared to the Sun drying that takes 5 days for about 13%MC. The final product is the coarse fishmeal as shown in figure 7. Itshould be grinded again before using as a feed mixed.



Fig. 7 Milled fish processing by-product

B)Fishmeal Qualities Evaluation

The dried fishmeal is grinded before qualities evaluation: protein content, fat content, ash, moisture content, calcium contentare calculated in a percentage of production yield. The result of fishmeal qualities evaluation from different fishmeal production are compared and shown in table 1.

Table 1 Fishmeal Qualities from Fish Processing By-product

Qualities list	Boiling &Stirring	Boiling &Pressure
Protein content %	31.14±1.31 [a]	34.98±1.15[b]
Fat %	5.74±1.24 [a]	6.21±2.23 [a]
Ash %	26.45±0.97 [a]	25.90±1.28 [a]
%MC	9.39±1.33 [a]	8.93±1.21[a]
Calcium %	9.68±2.63 [a]	10.25±2.17 [a]
Yield %	8.8	14.4

Remark: the same letter in row shows non-significantly difference

The fishmeal qualities from boiling with stirring process and boiling with pressure process show significantly difference in the protein content where the fishmeal from cooking of boiling with pressure gains about 35% of protein content higher than the fishmeal from cooking of boiling with stirring almost 4%. It may cause from stirring action during boiling and shows the loosing of solid more compared to the pressure cooked. This is also supported by the percentage of yield which is quite different between boiling with stirring process and boiling with pressure process at 6%. The yield of boiling with stirring process can process 1 ton of fish processing by-products to bethe fishmeal of 88 Kg and 144 kg for boiling with pressure process.

While three other qualities; fat content, calcium and ash show non-significantly difference between boiling with stirring process and boiling with pressure process.The fat content shows quite good compared to the commercial fishmeal which uses the screw compressor or screw expeller and fishmeal from catfish processing waste [7]. The deduction of oil content may come from the washing by hot water during screening after cooking. However, the manual cylinder compressor may not be in the same level of compression which is a mechanically force. If people want to improve its quality, the screw expeller is recommended. Percentage of ash shows at above 25% in both samples but it is lower thanthe fishmeal from catfish processing waste. This may be from soil and clay in the gut. Normally, Catfish live and eat on the ground but Tilapia does not. The good fishmeal should control at low level ash as much as possible, so using Tilapia processing waste instead of using Catfish processing waste.Head and gut of Catfish should be separated to deduct the ash.Calcium content from this experiment shows slightly high level at 9.86 and 10.25% for boiling with stirring process and boiling with pressure process respectively. Normally, calcium is needed for all formula feeds at about 1-3%. In this case the exceed calcium may cause some problems to animals. Regarding to debone during screening and washing only big bone are removed. It is discovered that if the calcium content needs to be deducted more,more bones should be removed.

For the moisture content in this experiment, the fish processing by-product fishmeal shows below 10%. It isa slightly low percentage of moisture content which is too low for commercial purpose. This occurs only by tray dryer used. For naturalSun drying the fish processing by-product fishmeal can be dried to 15% within 5 days and shorter if solar dryer is applied.

Overall qualities of fishmealfrom fish processing by-products both from boiling with stirring process and boiling with pressure process show non-significantly difference. The fishmeal fromboiling with pressure better in overall qualities and production yield. However, the low protein content become highly consideration for this process due to the protein content gains below 36% which slightly below the fishmeal class III (at above 40%) in both samples, it causes low price.

The fishmeal production from fish processing by-products is designed for sustainable aquaculture and can be simply adopted in 5 steps. First the fish processing by-product is cooked under pressure at 1 bar for 30 minutes, and then screening and pouring with hot water before removing the bones as much as possible. The cooked fish processing by-products is pressed or squeezed so water and oil comes out. After that the fish processing by-product cake is milled into small pellets and finally dried. Keeping of pellets fishmeal is recommended and they should be grinded whenever they are used.

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