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Foliar Fertilizer Production from Waste Fish

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Abstract: A foliar fertilizer is superior to regular solid types of fertilizers in terms of efficient assimilation by the cultivated plants. In this paper, production of foliar fertelizer is based on easy and low-cost process. A laboratory scale experiment was built to utilize waste fish and protease enzyme. The waste of Nga-myit-chin (bone, head and tail), freshwater and marine catfishes were selected for protein containging raw materials. ***Calotropis gigantea*** latex was chosen as protease enzyme. Proteolytic hydrolysis of waste fish was easy to set up. Macro and microelements present in fish hydrolysed solution were analysed by Kjeldahl method, flame photometry, Nessler˙s method and Atomic Absorption Spectroscopy. All the contents of macro and microelements in fish hydrolysed solutions were compatible with theoritical data. Thus the resulting fish hydrolysates were found to be suitable for foliar fertilizers.
Keywords: foliar fertilizer; waste fish; protease enzyme; catfish; ***Calotropic gigantea*** latex; macro and microelements; Kjeldahl

1. INTRODUCTION

There are several foliar fertilizers available on the world. A foliar fertilizer is a plant nutrient formulation, developed for application in the leaf. Foliar feeding is effective to solve nutrient deficiency in plants, and also to promote overall plant health.

In contrary to these, foliar fertilizer is available in true liquid form. In preparation of liquid fertilizer, specific amounts of major and minor nutrients are combined to get the desired fertilizer type. [1]

Ma-yo-gyi is a well known indigenous medicinal plant in tropical countries such as Myanmar, India, Parkistan and identified as ***Calotropis gigantea***. The latex from ***Calotropis gigantea*** can be utilized as an external medicine for removing piles, relief of pain of various teeth, curing leprosy and othe skin diseases. Latex is strongly irritant to skin and mucous membrame. [2]

Latex has been used as protease enzme in present work and large scale production may be done because collection of ***Calotropis gigantea*** latex is very easy and it can be obtained all year round like waste fish.

The present work is aimed to produce cheap and efficient foliar fertilizers from waste fish. Concentrations of macro and microelements in desired fish hydrolysates are compatible and suitable with literature. The resulting hydrolysed solutions can be used as foliar fertilizer for promotion and plant growth.

2. CONSTITUENTS OF FISH

Fish as a food is one of main sources of protein. The body of a fish contain many different chemicals namely protein, fat, water and certain minerals. About 60 elements have been identified in marine and fresh water organisms. The bulk, about 75 percent, consists of oxygen, about 10 percent of hydrogen, 9.5 percent of carbon, 2.5 to 3 percent of sulphur. Other elements are present in very small quantities.

Fish contains a large proportion of high grade protein wih all the amino acids essential for health and growth. Hence fish is very suitable for human consumption and animal feed and for manufacturing of products which can be used in pharmaceutical and textile industries. [3]

Table 1. Constituents of Selected Fish (Source: Wiseman 1977)

Species	Nitrogen substances (%)	Minerals (%)
Russian (Caspian and Azo) sturgeon	14.7 -19.7	0.8 -1.8
Siberian sturgeon	12.7 - 21.4	0.5 - 1.2
Chum Salmon	13.3 - 23.3	0.4 - 1.7
Atlantic herring	16.0 - 20.0	0.6 - 1.8
Caspian black- back herring	17.3 - 20.4	1.1 - 1.9
Anchovy	12.8 - 18.1	1.7 - 3.8
Atlantic ocean perch	16.0 - 19.7	1.0 - 1.8
Caspian roach	16.3 - 19.8	0.9 - 1.7
Bream: Caspian	15.1 - 22.1	0.9 - 1.7
Bream: Azov	14.7 - 18.2	0.9 - 1.2
Carp: Caspian	16.0 - 21.3	0.9 - 1.3
Carp: Azov	14.9 - 21.5	-
Carp: Amur	17.1 - 18.2	1.4 - 2.0
Sheat fish	15.1 - 20.2	0.9 - 1.2
Pike - perch	16.0 - 24.4	0.9 - 1.8
Cod	16.1 - 19.3	0.8 - 1.9

2.1 Protein in Fish

The protein content of flesh in fish has been evaluated in many species. This varies with size, age, sexual state or season of capture. [4]

Fish flesh also contains small quantities of protein substances (protenoid) that are not soluble either in water or in salt, alkaline or acid solution, and which are contained in the sarcolemma of the muscle fibres and connective tissue (myosepta and endomysium). These substances usually termed stromatic, or connective tissue proteins, consists mainly of collagen.

The muscular proteins are mainly in a colloidal state i.e in the form of gel and sol. This means that fish proteins are unstable and their propertities subject to change (denaturation) with a change in surroundings. The content of the more important amino acids in fish is given in Table 2. [5]

Table 2. Amino Acid in Fish (Source: Stansby 1976)

Amino Acid	Content (%)
Alanine	5.2 - 7.5
Aspartic acid	6.2 - 11.8
Glutamic acid	5.9 - 6.6
Glycine	1.0 - 5.6
Isoleucine	2.6 - 7.7
Leucine	3.9 - 18.0
Methionine	1.5 - 3.7
Serine	2.5 - 5.4
Threonine	0.6 - 6.2
Valine	0.6 - 9.4
Arginine	2.6 - 9.6
Lysine	4.1 - 14.4
Histidine	1.2 - 5.7
Phenylalanine	1.9 - 14.8
Proline	3.0 - 7.1
Trytophan	0.4 - 1.4
Tyrosine	1.3 - 5.0

2.2 Enzyme

Like the tissues of the animals, those of fish contains small quantity of many different enzymes, which acts as biological catalys in the chemical metabolism of proteins, carbonhydrates and fats, on which bodily functions depend. Chemically, enzymes are protein like substances, some being simple proteins and other complex proteins.

The enzyme that breaks down organic substances in fish known as autolysis is of great significance in the changes that occur after death. A particularly glycogen creatine phosphate and adenosine triphosphate (ATP) in the muscular tissues (phosphorylase, A-enzyme, amylase and ATP-ase), and muscular proteinase (cathepsins), which help to break down proteins, the most constituents of fish. The activity of enzyme system varies according to species and season. [4]

2.3 Latex Proteases

In plants, one of the rich sources of protease is latex. Over 110 latices of different plant families are known to contain at least one proteolytic enzyme. The primary role of protease in latices is defense against pets/ insects. Plant latex proteases exhibit both clot-inducing and clot-hydrolyzing properties. [6]

The latices of papaya and certain fig species have been known to contain powerful proteases. These proteases are commercially produced on a large scale and used in variety of industrial applications. The proteases in the latices of ***Ficus carica*** and ***Ficus glabrata*** (Moraceae), ***Asclepias*** and ***Calotropis*** (Asclepiadaceae), resemble the papaya very much. All are highly active cysteine proteases. [7]

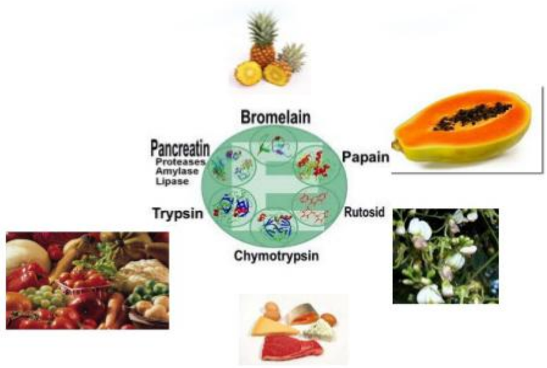

Figure 1. Proteases and their sources

2.4 Proteolytic Process

Proteolytic process is the breakdown of proteins into smaller polypeptides or amino acids. It serves many purposes in organisms; break down of protein and protein synthesis. It is important as an analytical tool for studying protein in laboratory and industry.

There are a number of proteolytic enzymes available for hydrolysing proteins. The choice of an enzyme for a particular use must be based on the specificity, pH optimum, heat stability, effect of activators and inhibitors, and the price and availability of enzyme needed. [8]

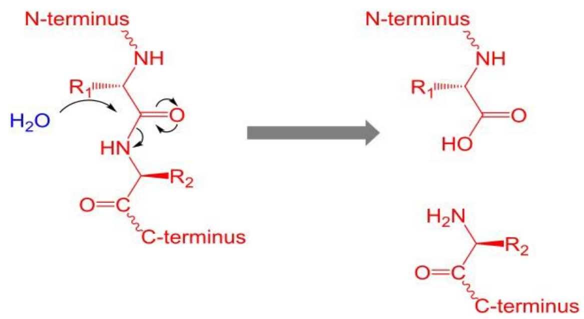

Figure 2. Proteolytic process in protein

2.5 Fish Solubles by Biological Means

Predigestion or hydrolysis of proteins by chemical means, whether acid or alkaline, is imperfect because of the racemization of amino acids, which then lose their biological value. Something similar happens with the processing of fish meal by conventional means, since the coagulation, precipitation and cooking with high heat causes the final product to be poor in its protein values.

Bertullo and Hetlich (1961) described a proteolytic yeast isolated from the liver of a common Brazilian fish, used for hydrolysing proteinaceous materials such as whole fish, fish remains etc, with it adding molasses and fermenting the mixture. The product was used as silage for animal feeding of for fertilizer.

Bertullo and Pereira (1970) have provided a method for the production of protein hydrolysates by means of proteolytic yeast, the hydrolysates servings as a food for human consumption. The resulting final product is a fine, pleasant smelling powder having a crude protein yield varying between 54 and 60%.[9]

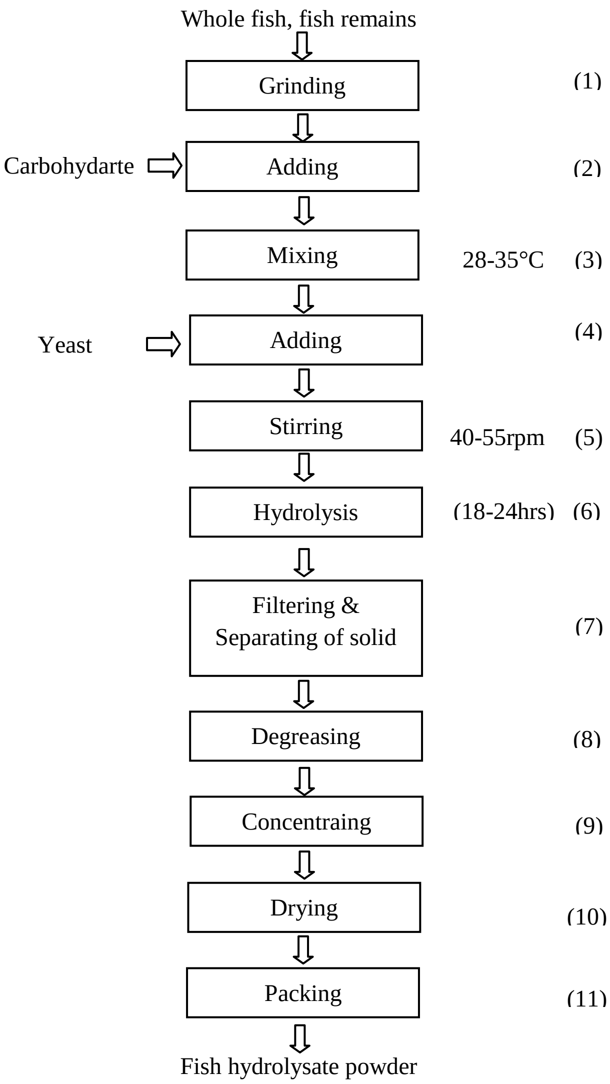

Figure 3. Proteolytic processing of Fish for Animal Use (Source: Fox 1980)

2.6 Amino Acid from Fish and Uses

Fish proteinsa are higher in nutritive value. They contain all of the essential amino acids in a balanced amount and are readily digestible and assailable. Fish protein can be used as a good raw material in amino acid preparation by hydrolysing proteins with acids, alkali or enzyme under specific temperature and pH conditions.

On hydrolysis the protein yields the following intermediate degradation products, namely, protease, peptone, polypeptides and finallly amino acids. Each method of proteolysis has certain limitations.

Amino acids and their salts could be administered to patients who suffer from gastrointestinal disorders or who have been continued and underfed for a prolonged period as in prison camps, or have severe burns of fractures, in which case, natural proteins can not be consumed. It is best to administer them by intravenous or parenteral injection, since pure amino acids have a disagreeable taste, when taken orally.[9]

2.7 Liquid Fish Fertilizer

In recent years, liquid fish has been diverted to use as organic type fertilizer.This usage is applied to the home gardener as providing an easily used material which can readily sprayed or poured on flowers or other home plants.

Liquid fish fertilizers come in different forms and qualities. Generally they are either emulsions or hydrolysates.

There are a number of advantages in using liquid fertilizers in contrast to dry fertilizers as follows:

(1) liquid fertilizers are relatively easier to apply and requires less labour to handle than by dry fertilizer,
(2) a more uniform distribution of fertilizer can be obtained by the use of efficient dispering machinery,
(3) fertilization and watering can be carried out simutaneously, and
(4) liquid fertilizer can not be blown away by strong wind as dry fertilizer can be.

2.8 Foliar Fertilization

Foliar feeding is a technique of feeding plants by applying liquid fertilizer directly to their leaves.[10] Plants are able to absorb essential elements through their leaves.[11] The absorption takes place through their stomata and also through their epidermis. Transport is usually faster through the stomata, but total absorption may be as great through the epidermis. Plants are also able to absorb nutrients through their bark.

Foliar Fertilization is the most efficient way to increase yield and plant health. Tests have shown that foliar feeding can increases yields from 12% to 25% when compared to conventional fertilization.

When fertilizers are foliar applied, more that 90% of the fertilizer is utilized by the plant. When a similar amount is applied to the soil, only 10 percent of it is utilized. In the sandy loam, folia fertilizers are up to 20 times more effective when compared to soil fertilizers. [12]

Foliar Feeding is a technique for feeding plants by applying liquid fertilizer directly to their leaves. The most touted benefit of foliar fertilizers is their capacity to promote maximum nutrient absorption. This is based on the belief that foliar fertilizers cause an increase in sugar levels in plants which then stimulate soil activity and plant nutrient uptake.

Foliar feeding is also finding favor among many organic gardeners. Organic gardening involves cultivating naturally healthy soil. This is a gradual process which can make it difficult to provide some trace nutrients in sufficient quantity. By foliar feeding, trace nutrients can be supplemented directly, without disrupting soil development.[13]

3. PRODUCTION PROCESS

Fishes were washed and chopped on a dressing table. All parts of sample were completely mixed to get uniform mass. 50 g of fish sample was mixed well with 6 ml of crude latex from ***Calotropis gigantea*** in conical flask by means of unitronic shaker. The flow diagram of foliar fertilizer production from waste fish was shown in Figure 4.

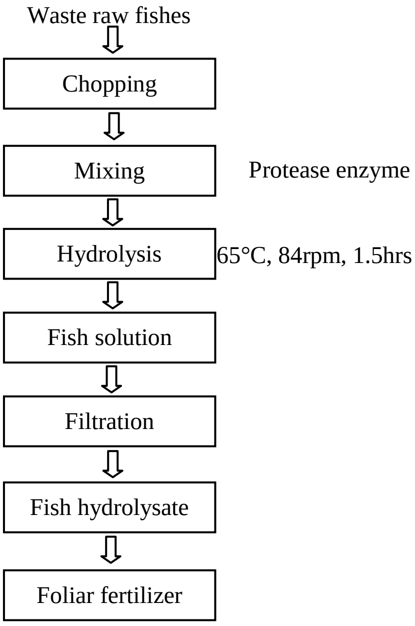

Figure 4. Production Process of foliar fertilizer from waste fish

3.1 Materials

Waste Fish (Nga-myit-chin) i.e, bone, head and tail
Catfish (Fresh water) i.e, the whole body
Catfish (Sea water) i.e, the whole body
Crude latex from ***Calotropis gigantea***

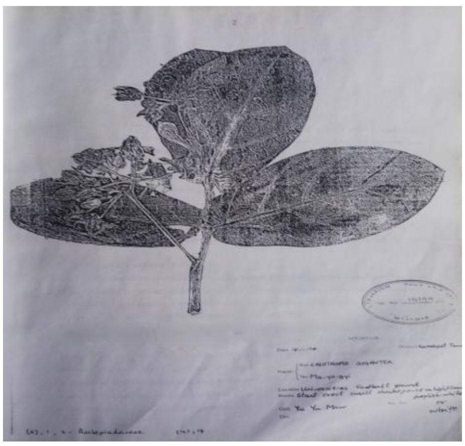

Figure 5. Identification of Ma-yo-gyi as *Calotropis gigantea*

3.2 Chemicals

Sodium hydroxide, phenolphthalein indicator, ascorbic acid, formalin, sulfuric acid (anlar) from B.D.H laboratory supplies, Poole, England

3.3 Determination of Macro and Micro elements in Fish Hydrolysate

Nitrgen contents in raw fish, residue and fish hydrolysate were determined by Kjeldahl method. Potassium and calcium were measured by flame photometry method. Nesslers method is employed to investigate phosphorus. Microelements such as Fe, Cu and Zn were quantitatively measured by Atomic Absorption Spectroscopy (AAS).

4. RESULTS OF ELEMENTS

Macro and micro elements in fish hydrolysate were determined by appropriate methos and expressed in Tables. Data of elements were based on three types of waste fish; Nga-myit-chin, freshwater catfish and marine catfish.

4.1 Nitrogen Contents in Selected Fishes

Table 3. Nitrogen Contents in Selected Fishes in Fish

Fish	Raw (%)	Hydrolysate solution	Residue (%)	Yield (%)
Nga-myit-chin	2.96	2.4	0.21	81.08
Catfish (fresh water)	2.27	1.62	0.38	71.37
Catfish (marine)	3.02	1.94	0.65	64.24

According to Ziatsev [14], 2.5% to 3% of nitrogen contents occurred in raw fish. Thus resulting nitrogen contents were nearly the same to those from literature.

4.2 Results of Macroelements in Fish Hydrolysate

Table 4. Amounts of Macroelements in Fish Hydrolysate

Fish	N (%)	P_2O_5 (%)	K_2O (%)	CaO (%)	MgO (%)
Nga-myit-chin	2.4	0.05	0.02	0.008	0.005
Catfish (Fresh water)	1.62	0.19	0.23	0.04	0.02
Catfish (marine)	1.94	0.11	0.26	0.06	0.04

Since plants require macroelements with milimole concentration (> 10^{-4}mol/l) [15, 16], all fish hydrolysed solutions were compatible with this approach. Thus the resulting solutions were suitable and satisfactory for using as fertilizer from view of macroelement.

4.3 Determination of Microelements

Table 5. Amounts of Macroelements in Fish Hydrolysate

Fish	Fe (ppm)	Cu (ppm)	Zn (ppm)
Nga-myit-chin	0.552	0.053	0.013
Catfish (Fresh water)	6.02	0.36	4.54
Catfish (marine)	8.21	0.37	6.56

Very small amounts of microelements are necessary for plant growth ($<10^{-4}$mol/l) [15, 16], and this fact is in agreement with constituents of the resulting solutions. Therefore the resulting solutions were satisfactory for use as fertilizer according to their compositions.

5. CONCLUSION

The aim of research work was to produce easy and low-cost foliar fertilizer for farmers and gardeners in Myanmar. Waste fishes (Nga-myit-chin, catfishes of freshwater and marine) were chosen as raw materials due to their abundance, locally availability and low price. Moreover they can be obtained the whole year round in Myanmar.

The choice of latex as protease enzyme in the present study depends on many factors because ***Calotropis gigantea*** can grow throughout in Myanmar and the latex collection from that plant is very easy. The latex can be used as crude without purifying.

Production processes are simple and easy for operating. Contents of micro and macroelements were detected by appropriate methods and results of present work indicated that fish hydrolysate was suitble for foliar fertilizer.

Finally, the present work had

(1) low cost for the production
(2) shorter period duration for the production
(3) more efficient decomposition of protein compared to the natural fermentation process and
(4) sufficient and balance nutrient contents for plant to upgrade their growth and development.

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