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Fusion of sugar industry and fish processing industry waste products in developing high value organic fertilizer and feed supplement

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Abstract

Sugar industries by-products (press mud, molasses, bagasse, etc). Fish processing waste (offal, fish processing rejects, rejects in fish retailing), prawn processing waste (head, exoskeleton, crabs waste, etc) to improve soil chemical, physical, microbiological and biological properties, aquaculture, pond productivity, crop productivity, foliar spray, fustigation and as organic fertilizer and bio organic pesticides, feed supplement and additives.

A huge possibilities of the above organic waste can be used in agriculture to cut down chemical fertilizer requirement.100kg of pressmud is recycled through agriculture about 3.2, 2.8, 1.4, 0.3 and 0.04, 0.1 and 0.03 kg of N, P, K, Fe, Zn, Mn and Cu respectively can be available and that help in saving of costly chemical fertilizer.100 kg of fish processing waste is recycled through integrated agriculture about 15.9, 5.0, 4.0, 0.2, 0.06, 0.04, 0.02 kg bio-available chelated nitrogen, phosphorus, potassium, haem-iron, manganese, copper and zinc in fish hydrolysate liquid organic fertilizer per one hundred liter. Similarly 100 kg of fish hydrolysate meal provides 3.0, 2.0, 0.7, 1.5, 10.4, 2.2, 1.8 kg bio available nitrogen, phosphorous, sulphur, boron, calcium, magnesium per one hundred kg of organic fish hydrolysate meal.

Keywords: organic fertilizer, processing, industry, supplement, sugar, fish

1. Introduction

Sugar cane industries and fish processing industries are age old industrial practices in India which constitute a significant amount of byproducts as waste. Handling and management of their by-products are huge task, because sugarcane waste requires a lot of storage spaces and that of fish processing waste is perishable and its spoilage emits foul smell and gas to the environment. However, both the by-products provide opportunity to utilize their by-products in agriculture, animal husbandry, fisheries as organic nutrient sources and feed supplement.

An attempt has been made to amalgamate_the potential sugar industry/fish and prawn processing industries by-product their availability, use in integrated Agri-Horti-Animal-Fisheries production. A large number of research experiments and literature have been reviewed and critically analyze in a nutritive content and their application in integrated agricultural production system.

Fish processing industry and fish markets produces more than 60% by-products as waste, which includes skin, heart, viscera, trimmings, liver, frames, bones and roes. These by- products contain good amount of protein rich nutrient material.

About 50% of world fish production considered as waste material, which means an expressive amount of 65.2 million metric tons of fish waste being generated globally. In addition, daily unsold fish as in markets and wastage during capture, commercialization and trash fish are regarded as low value and undesirable for human consumption, however they have potential as a feed stuff, fertilizer, animal feeds or crop fertilizers. (Kristinsson and Rasco, 2000) [27].

Shrimp processing generates considerable quantities of solid waste in the form of head and body carapace. These body parts comprise 48 – 56% depending on the species (Sachindra *et al*. 2005). Chitinous waste present a very important bioactive source and providing nutrients and effective micro-organism to further nourish soil properties.

Million tons of fish processing waste are being disposed off into environment through land filling or illegal dumping activities. Dumping at organic waste material into the environment will partly contribute to the global warming phenomenon due to methane gas generation through anaerobic process occurred inside the land fill or water beds of river and streams. Methane gas has 21 times higher global warming potential (GWP) than carbon dioxide and can severely affect the environment if not properly managed.

Novel means of processing are required to convert the under-utilize wastes and by-products into more marketable and accepted form, one alternative is to produce fish powders or fish protein hydrolysate that may be used as carbon and /nitrogen sources for biomass and metabolite production. Recognition of limited biological resources and increasing environmental pollution has emphasized the need for better and more value added utilization of underutilized fish and fish processing waste. Fish processing waste constitute around 50% in a fish are not commonly used in human feeding, and, most often they are disposed off, considering this impact of improper disposal of these residues on the environment and seeking suitable technology alternatives for a nobler use with both economic potential and social applications.

The current investigation is aimed primarily at the industrial application of the process. This posses constraints, particularly with respect to the overall cost efficiency of the scaled up process. Low cost and simplicity in operation, by reducing the cost of the material, energy consumption and labour, but maintaining high productivity are some of the important attributes that outline the direction of this investigation.

Traditionally, fish silage production is carried out by adding acids, mainly sulphuric, formic acid. This mixture is not very nutritious and acceptable for being used as animal feed and requires managing of strong acid. However, using other organic acid (acetic acid, lactic acid, propionic acid) involve high cost.

Bio-silage preparation using LAB cultures have been studies in all cases, and additional sources of carbohydrate had to be added in the form of molasses or dextrose 7-10%.However the control fermentation using LAB culture has been found to be costly proposition. Optimization of condition for natural fermentation of fresh water fish processing waste using sugarcane molasses and LAB culture has been standardized in producing a microbiology safe product by fermenting fish with molasses and salt under micro -aerobic condition. The entire organism was marginally lowered except for yeast and mold and lactic acid bacteria.

2. Objective

Amalgamation of sugarcane industries waste along with fisheries processing waste by-products can reduce the requirement of the fertilizer and improve organic matter on soil. During crop production, improve the chlorophyll and plankton production in ponds, used as a nuetraceutical, additive in animal feed, fish processing by-products co-processed with molasses will directly replace the use of fish meal in fish and poultry feeding.

In India many industries utilize the raw material for producing primary products and generate various types of wastes. Sugarcane and fisheries industries are most important amongst them. There is a growing concern among the scientific community, policy makers and scientist, industrialists, environmentalist for its proper disposal without compromising the ecosystem and environment.

Fish waste bio-masses are locally available resources which contain nutrients. Fermentation of the biomass produces slurries used for plankton production and plant/agri-nutri use. Bio-refinery of fish waste material can be converted into value added biological products such as bio-fuels, industrial chemicals, animal and fish feed, human food, neutraceuticals and organic fertilizer, etc. Fish processing waste could be regarded as promising renewable biomass resources for bio refineries. Hydrolysis of fish waste is aimed primarily at industrial application of the process. Low cost and simplicity of operation by reducing the cost of material, energy consumption and labour, but maintaining high productivity are some of the important attributes at the industrial application process. Fish hydrolysate generally shows a beneficial effect on growth performances is postulated to be due to the balance of free amino-acids, peptides and proteins in digestion, absorption and utilization.

3.1 Sugarcane Residual Waste

3.1.1 Press-mud:

The amount of sugar press mud (SPM) production depends upon the carbonation and sulphitation process. It is around 3-9 % of the total weight of sugar cane from above process (Sardar *et al* 2013) [40]. In general where 100 ton of sugar cane is crushed, about 3 ton of press mud are produced as by-product (Gupta *et al*, 2011) [19]. It is considered as rejected waste material of sugar cane industries that cause problem of storage and pollution to the surrounding of sugar mills or its accumulation (Bhosale *et al*, 2012) [5]. Press-mud is generated as the by-products of sugar cane industries are characterized as a soft, spongy, amorphous and dark brown to brownish material (Ghulam *et al*, 2012). Press-mud supplies good amount of organic matter and can be a alternate source of plant nutrients and act as a soil ameliorator (Bokhtiar *et al*, 2001; Rocha 2299, 2011) [34]. Press-mud contains 50 – 70 % moisture, which is most favorable for soil microorganism and earthworms. Press-mud is used as one of the substrate for bio composting (Chand *et al*, 2011) [7]. (Fig.1)

Fig 1: Sugarcane on conveyor belt

Press-mud is the solid waste produced while processing sugarcane press mud is rich in potassium, sodium, phosphorous and organic matters. Press-mud is a base material for producing bio – earth which is done by composting with spent wash, a liquid waste generated out of distillery separation. Sugarcane is versatile crop being rich sources of food (sucrose, jaggery and syrup) fiber (cellulose). Fodder green leaves and top of cane plants. fuel and chemicals (bagasse, molasses and alcohol and fertilizer (press-mud and spent wash)

SPM is also generated from alcohol distillation from the fermentation of sugarcane molasses. It contains huge quantities of water soluble plant nutrients and there is scope in utility in an organic fertilizer (Patil and Yadav, 2013) [31].

Table 1: Composition of Pressmud

Si. No.	Composition	Percentage (%)
1	Moisture	50-60
2	Fibre	20-30
3	Crude wax	7-15
4	Sugar	5-12
5	Crude Protein	5-10
6	Nitrogen	2-2.5

Press-mud contains 21% of organic carbon with macro and micro nutrients, which promotes microbes shows improved cat ion exchange capacity (CEC), and nutrient supply in the soil. Application of bagasse and press-mud improves physical condition of soil by reducing bulk density and enhanced macro pore for a better root growth and ultimately the productivity (Dey *et al* 1997) [13]. (Fig.2)

Fig 2: Sugarcane Juice

3.1.2 Molasses

Molasses is the by-product separates the "c" grade sugar during centrifugation of sugar crystals. The yield of molasses per ton of cane is in the range at 4 – 4.5 %. Molasses is the by-product of the sugarcane fining process. When sugarcane is mashed and boiled cane syrup is created. Boiling of juice yield, molasses and further gives blackstrap molasses. Refining processes just refuse to boiling process not other chemical processes. The molasses are super food, high in iron, B –vitamins, magnesium and other nutrients.

Nutritional values of molasses:

Molasses contains a number of essential minerals such as calcium magnesium, manganese, potassium, iron, copper, phosphorus, chromium, cobalt, and sodium. It is a good source of energy, carbohydrate and contains sugar aspartame. It contains various vitamins such as niacin, vitamins B -6, thiamine and riboflavin.

Molasses is a viscous liquid separated by centrifugation. It contains higher microbial activity and used for production of alcohol, ethanol. An average of one ton sugar cane produce 23L of molasses (Sardar *et al*, 2013) [40]. (Fig.3)

Fig 3: Molasses is being filled in the tank

Table 2: Composition of molasses

Si. No.	Constitution	Percentage (%)
1	Sucrose	30-35
2	Glucose and galactose	10-25
3	Moisture	23-23.5
4	Ash	16-16.5
5	Calcium and potassium	4.0-5.0
6	Non sugar components	2-3
7	Other mineral contents	1-2

Molasses are most economically important by-product having in industrial use in alcohol production, animal feed and food stuff. Molasses containing large fraction of fermentation sugar, is diluted three times with water and allowed to ferment in presences of yeast culture (*Saccharomyces cerevisiae*) by batch or continuous process or fermentation. Fermentable sugar is converted into alcohol and lower order sugar (dioses, triose, tetrose, pentose) water soluble amino acid, lignins and other organic fraction etc in spent wash. (Fig.4)

Fig 4: Molasses Tank

3.1.3 Bagasse
Bagasse is the residue from the sugarcane after extracting cane juice. Bagasse is used to produce and powder by using bagasse for high pressure boilers in the cogeneration of power plant. Bagasse yield is 30% of the cane cultured. Bagasse contains major portion as cellulose, hemicelluloses and ligrin are 47-52, 25-28, and 20-21%, respectively and ashes 0.8- 3% (Rocha *et al*, 2011) [34]. (Fig.5)

Fig 5: Sugarcane bagasse

3.1.4 Waste water of sugar manufacturing process
Indian sugar mills generates 0.16 – 0.76 m^3 or wate water for every tonnes of cane crushed by them. The combined sugar mill waste water has BOD of 1000 to 15000 mg / l. Pollution standards stipulated less than 30mg / l for disposal inlam surface water. less than 100mg/l for land application or treated waste water for a secondary treatment system for further removal of BOD. Sugar mill waste water is relatively clean, however the stagnation of water for some time turn into black starts emitting other than discharged in water pump, its high BOD duplicates dissolved oxygen makes the environment sumit for fish and aqutic life.
Sugar Mill waste water contains large quantities or biodegradable waste water. aerobic biological processes like oxidation probes and bio-methenation have several advantages. anaerobic processes are easy to control, oxygen not required and requires less quantity.
Bagasse, molasses, pressmud, waste water and Hg ash are produced during manufacture of sugar. Sugar mill waste water has loose BOD. The distillery waste water is low pH, highly controlled and very high in BOD. Bagasse sand waste water is alkaline in nature.

3.1.5 Spent wash
The raw spent wash is generated after fermentation and distillation is acidic in nature havind dark brown color and unpleasant odoure high COD and BOD (1 lakhs and 45,000 mg L^{-1}) biomethenation with primary treatment produced 1100 million cubic test of methane gas and used for steam generation in boilers.
Bio-methenated spent wash contain plants extracts and microbial reservoir (Kulkarni *et al*., 1987)
The by-product of these pro induction are bulky, voluminous, suitable technologies could be developed to reduced there voluminar to cheapes concentrated end products. Composting processes is the suitable option for reducing the volume of the by-products. it can be used in fertilizer industries as the carrier of nutrients. Customize organic and inorganic fertilizer can be developed for particular cropping system or region.
Spent wash produced from the industry can be used as liquid fertilizer. Due to its acidic nature with high organic matter it can be used as soil ammenbient in solid soil. Permanently the cost or chemical fertilizer and pesticides are skyrockling and not aroundable by farmer the organic fertilizer prepared from the amalgamatia of these two industrial by-products, has promise as a source of plant nutrients, seedling raising, leguminous inoculants, an economically reliable technology has been developed for the complete package of practices for crops, animal, poultry and fish feed, foliar spray, bio-ameliorants.
Disposal of sugar industry spent wash (vinasse) by composting with pressmud cave through microbial consumption treatment by pit and window system indicated the executive of microbial dumping culture.

Table 3: Solid waste quality in sugar industry

Serial number	Parameter	Sludge	Filter cake
1	Nitrogen (%)	1.35	0.35
2	Phosphorus (%)	0.45	0.52
3	Calcium (%)	0.06	0.29
4	Carbon (%)	14.51	16.34

On production of good quality composed in a short period of time and contained 1.52-3.7% -N, 0.9-3.54% - P_2O_5, 1.95-3.45% - K_2O and had pH range from 7.40-8.16.window system of compost was better in comparison to pit composting. Efficiency of effluent utilization from sugarcane industry was achieved (Mahamum and Patil, 2012) [31].
India produces on average of 270 million tons of sugarcane per year. Environmental penetration has become a strategic issue that involves innovation, adoption of technology, and increases productivity.
Sugar industry, aquaculture and fish processing industries have high pollution potential. the purpose of this study is to extain the possibility of waste management use and control of waste and possible attention for its use. analysis of possible waste management, reuse them in production of other products, decreasing environmental impacts, improveing the perception of sustainability. Distractibility production while increasing competitor.

3.1.6 Scope of utilization of press mud
The sugar industry is the second largest agricultural industry in the country after the textile industry. It has a lot of

importance in Indian agriculture. India has more than 45 million sugarcane growers and about 65% of the rural population depends on this agro-based industry.

Sugarcane cultivation and sugar processing struggling for energy with cost of production, utilization of each and every components of sugarcane processing and their by-products can lead to sustainable, eco-friendly and economies (Dotania *et al*. 2015) [15].

Maharashtra sugar industry is one of the most notable and large scale sugar manufacturing sector in the country. Sugarcane industry generates lots of waste by-products like bagasse and pressmud. (Fig.6)

Fig 6: Pressmud from sugar industry

There is a growing concern among scientific community, policy make, industrialization and environmentalist for in rate disposal without compromising ecosystem.

Pressmud is a organic waste is also called liter cake. Pressmud is generated during the purification of sugar or sulphitation process. The process separates clear juice on top and mud at the bottom. Crushing 100 Tons of sugarcane about 3 Tons of Pressmud are produced as a byproducts (Gupta *et al*., 2011) [19] pressmud cause problem of storage and pollution to surrounding of Sugar Mills on its accumulation (Bhosale *et al.*, 2012) [5].

Sugar press mud (SPM) compositions are given in table 4. SPM contains 50-70%mixture and sugar enhances in decomposition in soil. Alternate source of plant nutrient and act as soil ameliorates. Sugar and moisture are most favorable for soil microorganism, especially earthworm (Dominguez, 1997).

Table 4: Chemical composition of pressmud

Serial number	Constituents	%
1	Moisture	50-65
2	Fiber	20-30
3	Crude wax	7-15
4	Sugar	5-12
5	Crude protein	5-10
6	Nitrogen	2-2.5
7	Bacteria, fungi, actinomycetes, Microbial activities.	Positive

SPM contains significant amount of iron, manganese, calcium, magnesium, silicon, and phosphorous. Pressmud is a by-product of sugar industry is used as a substrate for bio-composting. (Chand *et al*., 2011) [7].

SPM is also generated from fermentation of sugarcane molasses during alcohol distillation and contain huge volume of waste and plant nutrients. The distillery SPM may be treated with bio fertilizer on other nutrients by-products for agricultural crop production (Patil *et al*., 2013) [31].

The integrated use of SPM with nitrogen fertilizer has enhanced the any matters, cane and sugar yield (Bangar, *et al*., 2010). SPM supplies carbon to soil microorganism. The macro and micro nutrient of soil also increases. Recycling of organic waste by applying into agricultural seems to be a good option. Adding or incorporation of fish based organic liquid and solid waste seems to be a good option, to enhance out the waste storage, disposal problem and storage of plant nutrients, feed and fertilizer requirements. It will improve the quality and reduced the quantity of requirement from 25 to per hectre to 2.5 tons per hectare i.e. one of the volumes. It can become a common farm practice for agriculture, horticulture and rejected crops.

Sugarcane waste as organic fertilizer is a bio-resourcer utilized for agriculture for improving soil fertility, productivity, growth, yield or crops. Due to intensive cropping, exploitative agriculture soil fertility cannot be maintained on a sustainable basis. The use of optimum level of N, P and K has failed to maintained yield levels, due to increasing deficiency and alternation of physical and chemical properties of soil.

3.1.7 Organic residue as soil amendment:

Addition of organic residue to soil accelerates microbial activity in soil. Due to easily available carbon as food material (Singh *et al*, 2001) [13].

Table 5: Constituents of spent wash and distillery

Serial number	Constituents of constituents	Spentwash and distillery water (%)
1	Water	90-93
2	Solids	7-9
3	Organic solids	75
4	Inorganic solids	25
5	Colloidal nitrogen, phorous, calcium, sulphur, magnesium, manganese, copper and zinc	Present
6	Distillery effluents: N, P, K, sulphur, calcium and sodium, sulphate and chlorides.	Present
7	pH acidic	3.8 to 4.0
8	Amendment for Alkaline soil.	
9	BOD	45,000-55,000 mgL^{-1}
10	COD	90,000-110,000 mgL^{-1}
11	Total solids	80,000-90,000 mgL^{-1}

(Devarajan et *al.*, 1996. Dotania et *al.*, 2014) [15]

Direct application of concentrated spent wash on agriculture may lead to nutritional and environmental problems due to high salinity, low phosphorous content and high density liquid. Press mud is sprayed with spent wash and composted.

Under thermophilic and anaerobic conditions microbes have ability to decolorize molasses waste water. *Pseudomonas, Enterobacter, Stenotrophomonas, Aeromonas, Acenetebacter* and *Klebsiella* are efficient in reducing COD of spent wash.

Bio compost is prepared by mixing pressmud and distillery spent wash in the ratio or 1:2.5 of efficient microbial decomposers, viz., *Phanerocheate chrysosporium, Trichurus spiralis, Pacelomyces fusisporus, Trichoderma* spp., sprayed mixed by aero-tiller to hasten the process of decomposition for 8 weeks.

4.1 Fish Processing Residual Waste

4.1.1 Fishery Waste as a Raw Material for Bio-Refinery System

Bio-refineries are defined as the sustainable processing of biomass into a spectrum of marketable product and energy. Bio-refinery of fish waste material can be converted into value added biological products such as bio-fuels, industrial chemicals, animal and fish feed, human food, neutraceuticals and organic fertilizer etc. Fish processing waste comes under high value organic fractions. Organic fractions of the waste material can be regarded as biomass. Therefore, the term bio-refinery is derived from the words biomass and refinery. Fish processing waste could be regarded as a promising renewable biomass resource for bio-refineries. Hydrolysis of fish waste is aimed primarily at industrial applications of the process. Low cost and simplicity of operation by reducing the cost of material, energy consumption and labour, but maintaining high productivity are some of the important attributes at the industrial application process.

4.1.2 Green Processing Of Fishery Waste

Fishing industry creates large amount of waste every year. So there is increase demand for effective and ecological techniques to treat their waste. Biological fermentation of fish waste treat leads to organic fertilizer for potential use in animal and poultry feeds. Natural fermentation of fish waste are the process virtually independent from scale, the technology is simple, the investment is little even in large scale production, reduced effluents and odour problems. (Gao *et al*., 2006; Sahu, *et al*., 2016 a; 2016 b) [17, 38] Acidic condition of fermentation can help to recover calcium to aqueous solution and increasing the nutritional value of the hydrolysate. Fermentation of fish waste is more suitable and convenient for small industries and farmers biological fermentation using lactic acid bacteria which exist naturally in the raw material or are introduced as starter culture (Vazquez, *et al*., 2008). Fermentation has been studied as biological process to preserve fish waste through mixed fermentation (alcoholic/lactic) and also to remove the pungent odour. pH decrease in product gives evidence of a good acidification through lactic acid fermentation. The most important factor to control in the biotransformation is the pH decrease which must be achieved as quickly as possible in order to inhibit the growth of spoilage microorganisms in the product. Lactic acid fermentation is usually accompanied by some metabolites (bacteriocins), which may help in preservation of fermented foods. An increase in the acid degree value (ADV) of the fat in the product is observed during the initial stage of the fermentation. The ADV increase may be due to the lipid breakdown by the lipolytic microorganisms and/or their lipases. The phenomenon is likely to occur during the 1st stage of fermentation, while the pH is still about neutral so that lipolytic microorganisms can grow and consequently release their lipases. This process releases free fatty acids into the medium (Gao *et al*., 2006; Dao and Kim, 2011; Kim and Lee, 2009) [17, 12, 26]. Reduction of lipids in fish meal prepared from fish waste by yeast Yarrowia lipolytica leads to enhanced product quality during storage (Yaro *et al*., 2008). Increase in non-protein nitrogen (NPN) during fermentation indicate protein breakdown leading to release of amino acids and other metabolites originating from proteins. Natural fermentation process results in continuous removal of trimethylamine produced by production of gas by yeast culture or ta a delay in formation of trimethylamine by creating conditions in the product unfavourable for the microorganisms involved in transforming the protein in such compounds (Clausen *et al*., 1985) [10].

4.1.3 Fish Waste Hydrolysates

Fish internal organs represent rich sources of enzymes and many of these exhibit high catalytic activities at relatively low concentration (Kim and Mendis, 2006) [26]. Hydrolysis processes have been developed to convert underutilized fish and fish by-products into the maketable and acceptable forms. Fish hydrolysate generally shows a beneficial effect on growth performances and feed utilization at low inclusion levels. The performance is postulated to be due to the balance of free amino acids, peptides and proteins in digestion, absorption and utilization. Sahidi *et al*., 1995 [36] confirmed that amino acid profile of protein hydrolysate is generally similar to the raw material except for sensitive amino acids such as methionine and tryptophan. Bhaskar *et al*., 2008 [32], optimized the enzymatic hydrolysis of visceral waste proteins of Catla (*Catla catla*) for preparing protein hydrolysate using a commercial protease. Fish by-products contains the same valuable proteins as the fish muscle. Recovery and alteration of protein present in the fish by-product is a feasible alternative. By using fermentation and enzyme technology, it may be possible to produce a broad spectrum of food, feed and fertilizer ingredients for wide range of applications (Rustad *et al*., 2011) [35]. Enzymatic hydrolysis of fish frames using papain in a pilot plant produced fish protein hydrolysate. Amino acid profile of fish protein hydrolysate was identical to that of parent substrates (fish frames) (Himonides *et al*., 2011) [21]. (Fig.7)

Fig 7: Fish processing waste

4.1.4 Prawn Waste Hydrolysate

The amount of prawn processing waste can be upto 65% of initial shrimp weight and it constitutes an environmental problem. The chitin content percentage (c %) of prawn waste (dry basis) varies from 14% to 30%. The percentage of weight of protein and mineral salts can be upto 40% and 35% respectively. Shrimp waste is an important source of bioactive molecules. Shrimp biowaste is an important natural source of carotenoids particularly that of astaxanthin and its esters. Use of strong acid and alkali in bioconversion of fish and prawn waste is ecologically aggressive and a source of pollution. The process also renders the protein component useless for making feed material. Traditional fermentation depends on naturally occurring microorganisms in the substrate. Spontaneous fermentation has been optimized through back slopping i.e., inoculation of the raw materials with a small quantity of previously performed successful fermentation. Spontaneous fermentation with previously performed inoculum, sugar and yeast ensures rapid acidification to conduct ensilation for converting fishery waste into industrial products. The low pH inhibits the growth of unwanted microorganisms. Molasses has been used as sugar source for lactic acid fermentation for preparation of silage. Molasses assisted in fermentation process is relatively inexpensive and acceptable to animals (Arbia *et al*., 2013) [2]. During spontaneous fermentation protein and calcium removal is achieved by enzymatic actions and solubilization of calcium by organic acids. Spontaneous fermentation protect from microbial degradation allowing proteolytic enzymes present in muscle or viscera to liquefy and hydrolyze protein into short peptides and some of them are degraded into free amino acids (Cao, *et al*., 2008). Jaggery or molasses are cheap source of sucrose and sucrose is reported to be an ideal carbohydrate source for lactic acid bacterial fermentation (Cira *et al*., 2002) [9]. This technique and material should be used to economically present shrimp waste and made into fertilizer and feed for aquaculture and agriculture uses. Prawn waste hydrolysate contain large amount of pigments, mainly astaxanthin. The recovery and applications of added value products is of increasing interest. Chitin and chitosans in deacetylated form are applied in water treatment, agriculture and dietary supplement (Zhao, *et al*., 2010) [45]. Chitin deacetylases play very important roles in the biological attack and defense systems; they may find applications for the biological control of fungal plant pathogens or insects, pests in agriculture and for the bio control of opportunistic fungal human pathogens. Silage preparation of prawn processing waste using molasses and yeast has been reported to be a good and economical technique to protect these biomasses from bacterial decomposition. Prawn processing by-products contain some value added nutrients for the aquaculture industry such as carotenoid pigment (mainly astaxanthin) and n-3 poly unsaturated fatty acids. Organic wastes from fish and prawn has been found to contain compounds capable of promoting plant growth. Shrimp carotenoid increases the resistance of common carp fingerlings to ammonia induced struss. Carotenoids would find use as the pigment source in feed for ornamental fish, salmon and prawn culture. Invitro antioxidant activity of liquor from fermented shrimp biowaste reveals the antioxidants activity of the shrimp waste liquor (Babu *et al*., 2008) [3]. Carotenoids are prone to degradation by acids; mild treatment such as fermentation may have beneficial effect on stability of carotenoids. Bio conversion of shrimp shell and head waste for biofungicide production (Wang *et al*., 2011) [43] purified Chitinasa inhibited the hyphae extension of the phyto pathogenic fungi. (Fig.8)

Fig 8: Prawn processing waste

4.1.5 Antifungal Properties of Prawn Waste Hydrolysate

The acid/alkali liquid waste from Chitin production process could be a feed stock for antifungal material production. F. oxysporum a fungal phytopathogen equals damping off disease and the antifungal agents formed in chitin and chitosom showed suppression of swelling and lysis of hyphae. Antifungal chitinase produced by Bacillus cereus with shrimp and crab shell powder have good antifungal properties (Chang *et al*., 2003) [8]. Chitin, chitosan, peptides have antioxidative and anticarcinogenic properties. Shrimp shell wastes are rich source of phenolic compounds which play an important role in antioxidant, antimicrobial, anti-inflammatory and valodilating effects. Shrimp shell hydrolysates are rich in compounds with amino groups to enhance its antioxidant properties. It is expected that this bioactive material rich liquor have beneficial biological functions owing to inherent protein, chitin hydrolysis, astaxanthin, antifungal agent and other bioactive material produced during fermentation (Wang *et al*., 2005) [8].

4.1.6 Application of Fish Hydrolysate in Agriculture

The beneficial chemical composition of fish protein hydrolysate and fish protein concentrate has led to using their material as fertilizer, plant nutrients, fish and animal feed (Kristinsson and Rasco, 2000) [27]. Novel application taking advantage of plant growth stimulating effect of the fish hydrolysate has been studied extensively. Fish protein hydrolysate could well become a proline and amino acid substitute in plant-tissue culture applications. The positive effect of fish hydrolysate due to proline and glutamate on plant growth was confirmed in a study (Milazzo *et al*., 1999) [29]. Proline and glutamate obtained from fish hydrolysate can be used for value added applications in plant propagation industry (Eguschi *et al*., 1997) [16]. Addition of fermented fish protein hydrolysate called plant catalysts at 3 lit/acre dose right from pre-plantation stage improve paddy yield between 20-30%. Application of fish hydrolysate helped in eradication of stunted growth and yield improvement (Marimuthu *et al*., 2009) [28].

4.1.7 Sachharides of Chitoligo Present in the Shrimp Shell Hydrolysate

The mixture of chitoligo polymers have high antioxidant activity and have antitumor activity. There is a growing interest to convert chitin and chitosan into their oligomers that have better functional properties and improved absorption through human digestive tract. Enzymatic hydrolysis is more preferable for the preparation of oligomers, since this method results greater yield of oligomers with higher degree of polymerization. Chitin and chitosan derivatives have shown good potential for removal of various aquatic pollutants. Treatment of water and waste water utilizing chitin and chitosan derivatives for removal of metal cations and metal anions, radionuclides, dyes, phenol substituted protein anions and different miscellaneous pollutants (Bhatnagar and Sillanpaa, 2009) [4]. Chitinous waste are very important organic fertilizer sources. In addition to their antifungal powers they also have a role in plant growth regulation and plant self-defense induction. A change in microbial composition of the rhizosphere of Triticum durum wheat resulted elimination of phytopathogenic fungi, stimulation of secretion of growth hormones, secretion of antibacterial metabolites and reduced phytotoxic microbial community (Tan *et al*., 2010; Aizi and Cheba, 2015) [42, 1]. Leucine is an essential amino acid detected in shrimp head hydrolysates are good for animal feeding. Glutamic acid, aspartic acid, alanine and glycine are known to be flavor enhancers in shrimp head hydrolysates (Randriamahatody *et al*., 2011). Lime treatment of shrimp head waste produced a highly digestible animal feed (Coward-kelly *et al*., 2006) [11]. Fish waste and shrimp head silage has been reported to be dietary sources for Nile tilapia (Srour, 2009) [41]. The development of aquaculture hampered by inadequate supply of feed stuff, particularly fish meal which is scarce and expensive.

4.1.8 Plant Use Applications of Fish Hydrolysate

Wyatt and Mc Gourty (1990) [44] received the use of fish fertilizer on agricultural crops and reported that fish fertilizer use increase the vigor and growth of plants. Liquid fish fertilizer used as spread sticker in tree fruits to maintain the health of bud wood and also the vigor of trees, control of codling moth and other moth pests by spraying this fertilizer. Fish fertilizer used by table grape growers as a foliar feed to control bunch size and shape, fruit size and sugar content. Fish fertilizer provide growth hormones, trace minerals, elements and nitrogen necessary for plant tissue production. Pure inorganic nitrogen use makes explosive nitrogen response. Explosive nitrogen response is rapid and gives weeds an unwanted advantage. Nursery operator and fruit growers could benefit from increased nitrogen efficiency while using fish fertilizer. Foliar spray and side dressing at the time of transplanting vegetables crops reduces stress and increases survivability and promotes growth potential. Studies on radish, tomatoes, corn, strawberry, lettuce, soybean, papers have demonstrated growth promoting potential. Fish Fertilizer mixture is being used by growers of corn, soybean and horticultural crops during blooming, flowering or at other critical times in the life history of plants. Household plant growers have learnt that fish fertilizer can be used as sole source of nutrients for house plants and ornamentals.

5. Product Development from Fish Processing Residues

Proximate chemical compositions of liquid fish hydrolysate are present in Table-1.such composition shows the potential of fish hydrolysate as a source of proteins, lipids and minerals. Natural fermentation took place in silage prepared with fish waste without any inoculation. pH and microbiological parameters have been presented in Table-6. pH was used as an indicator of the courses of fermentation. A successful fermentation was obtained as evidence by a rapid pH decline to reach a stable value of 4.2 on 28th day of fermentation.

Table 6: chemical composition of protein hydrolysate from fish processing waste.

Parameter	Composition
Total Nitrogen (%)	1.51 ± 0.23
Total Phosphorous (%)	0.52 ± 0.11
Total Potassium (%)	0.40 ± 0.15
Fe (ppm)	240.5 ± 32.2
Mn (ppm)	6.2 ± 0.3
Cu (ppm)	3.5 ± 0.5
Zn(ppm)	1.8 ± 0.3

Table 7: Chemical properties of fish hydrolysate as bio fertilizer

Parameter	Composition
pH	4.25 ± 0.2
Mv	162.0 ± 11.0
Organic Carbon (%)	2.2 ± 0.2
Available nitrogen (mg) in 100mL	392 ± 0.21
Available phosphorus (mg) in 100mL	10 ±0.5
C/N ratio	1.5

Thereafter the liquid hydrolysate and the hydrolysates meal were separated. The yield of liquid and solid was in the proportion of 3:2 parts respectively. The prepared liquid hydrolysate and hydrolysate meal showed a stable Ph during 3 months of storage and had a fresh strong acidic smell without fishy odour. More liquefaction of the sample was observed with successful fermentation. This could be attributed to low pH which enhanced the action of fish proteases on proteins. Successful natural fermentation was observed between25-35^{0}C. (Fig.9)

Fig 9: Preparation for fish waste recycling

The stable fish hydrolysate can be prepared at ambient temperature with natural fermentation with concomitant saving of energy and equipment. In tropical and subtropical countries natural fermentation of fish hydrolysate can be made. The phase of increased in histamine level with increased pH. The pH range between 5.0 and 6.5 produced more Histamine. Reduction of pH level decreases the biogenic amines production from free amino acids by autolytic decarboxylation of microbial enzymes.

The results of Table -2 shows that 5-7 days are necessary before the pH drop become significant such phenomenon may be partially due to the relatively low initial number of the desirable flora namely, LAB, and to the conditions of the fish molasses mixture, in particular the high soluble carbohydrate of the added molasses. (Fig.10)

Fig 10: Small scale bio-refinery

However, the relatively high ratio of molasses in the starting plays a beneficial role via the osmotic pressure effects in inhibiting the growth of some spoilage bacteria before the biological acidity reaches an inhibiting level. Table-8 indicates the microbiological traits of naturally fermented fish processing waste.

Table 8: Microbiological traits of naturally fermented fish processing waste

Period of fermentation	pH	Total plate count (cfu/mL)	Total mold count (cfu/mL)	LAB count (cfu/mL)
Starting day	6.2 ± 0.3	8 ×10^4	5 ×10^2	18 ×10^2
7 Days	5.4 ± 0.2	15 ×10^9	8 ×10^4	5 ×10^3
14 Days	4.4 ± 0.5	12 ×10^6	3 ×10^4	10 ×10^3
21 Days	4.2 ± 0.6	9 ×10^5	4 ×10^3	16 ×10^3
28 Days	4.0 ± 0.5	11 ×10^4	15 ×10^2	21 ×10^3

All values are average of triplicate sample

The proximate composition of fish hydrolysate meal and fish bio fertilizer is presented in Table-9. The fish hydrolysate meal and fish bio-fert contains around 2.5-3% Nitrogen and a fairly good amount of micronutrients which can be utilized in agriculture, horticulture and aquaculture activities as a potent bio-fertilizer.

Table 9: Proximate composition of fish hydrolysate meal and fish biofertilizer.

Constituent	Hydrolysate meal	Fish Bio Fert
Electrical Conductivity (ds/m)	5.07	2.98
Organic Carbon (%)	33.67	31.01
Total Nitrogen (%)	2.95	2.56
Total Phosphorous (%)	1.98	0.96
Total Potassium (%)	0.65	1.20
Sulphur (%)	1.52	1.51
Boron (%)	10.4	39.0
Calcium (%)	2.24	1.55
Magnesium (%)	1.75	0.07
pH	4.82	5.03

The cost effectiveness of converting fish waste into liquid bio-fertilizer (Fish hydrolysate) and powered bio-fertilizer (Fish bio-fert) has been presented in Table-10.

Table 10: Cost effectiveness of converting fish waste into liquid and powdered fish bio-fertilizer**.**

Category	Cost Per Unit(INR)	Cost(INR)
Fish Waste Transperation (25Kg)	3	75
Molasses 25kg	15	375
Plastic drum 7	250	1750
Stirring paddle	500	500
Chemical Phosphoric acid	300	300
Bottling and 301 packaging	25	750
Dry fish manure 15kg 15*4 60 kg oil cake Total=75 kg	35	2100
Labor cost men month	3000	3000
Electricity 50 unit	6	300
Cost of production	30L(LBF)and 75kg (BFM)	9150
Category of product	Cost per unit(INR)	Cost(INR)
Fish hydrolysate 30L	150 INR	4500
Fish Biofert 75 kg	100 INR	7500
Total		12000

Cost of production: 9150 INR; cost of product: 12000 INR; Benefit to cost Ratio (B/C):0.42

5.1 Amalgamation of Fish Waste and Sugarcane Waste

Fish and prawn processing waste disposal is a huge cost burden. The efficient recycling and utilization of fish processing waste would help create a more sustainable eco-system. Million tons of fish processing wastes are being disposed off into environment through land filling and illegal dumping activities, which partly contribute to the global warming potential, 21 times more than carbon dioxide. Fish processing waste biomass have high value organic fractions. Refinement of biomass is undertaken by our technology through Bio-refinery. (Fig.11)

Fig 11: By-products of sugar cane processing industry

"Fish Bio refineries" are defined as sustainable processing of fish waste biomass into a spectrum of marketable product and energy for crop, animal and fish farming. Fish processing waste are promising renewable biomass.

Fish processing waste constitute around 40% in a fish are not commonly used in human feeding and most often they are disposed off, considering the impact of improper disposal of these residues on environmental and seeking suitable technological alternatives for a nobel use with both economic potential and social implication. Recognition of limited biological resource and increasing environmental pollution has emphasized the need for better and more value added utilization of underutilized fish and fish processing wastes. (Fig.12)

Fig 12: Bio-refinery products developed from fish waste

The industrial application of fish hydrolysate production process is simple, low operation cost, less labor and energy consumption but maintains high productivity. The underutilized fish species along with the large quantities of processing wastes generated from fish and processing industry and fish markets forms an excellent resources material for production of values added organic fertilizer and bio supplements. These waste materials would not only eliminate all environmental concerns of waste disposal but also improve the overall economics of commercial Agri-Horti-Aqua farming system in a sustainable manner.

Conclusion

Major challenges and opportunities: Sugar industry waste

Sugar mills in the country produce d large amount of waste as their by –products disposal and managements of the waste is the major task. Major chunk of by-products are used in agriculture for organic fertilizer and compost production. Sugarcane waste are voluminous and involves transportations cost to the applications sites.

Therefore the objectives our researches to reduce their voluminous to cheaper concentrated products. Composting is the process to reduce the volume to cheaper concentrated product and can be used fertilizer industries as carrier of nutrients. These products are used in organic farming for crop production, soil orientation organic sources of nutrients to plants medium for microbial inoculants for bio fertilizer and bio compost production. Customized organic fertilizer can be produced by amalgamating the organic fertilizer from fish waste for agricultural, horticultural and vegetable crops. Both the sugar industry waste and fish processing waste are acidic with high nutrient value. Then products are ameliorants for sodic soils. Packaging and marketing of their waste into products will popularized and accelerate the uses through value addition.

Fish Waste Recycling

Fishery waste occurs in all stages of fish production value chain from grower to processors, to super markets and consumers. (Gustavsson *et al*., 2011) [20]. One solution to secure food production, prevent depletion of fisher resources and decrease food waste may be found in the concept of the circular economy (CE). By means of closed loop fish production chains, efficiency or resource use increases and a better balance between economy, environment and society may be found (Ghisellini *et al*., 2015). Circular economy (CE) in fishery sector comes from the involvement of all actors of the society and their capacity to link and create suitable collaboration and exchange patterns (Dittrich *et al*., 2015) [14] Success stories also point out the need for an economic return on investment, involve to provide suitable motivation. Circular business models for fishery waste aims to create solution for environmental issues by integrating novel scientific insights and technologies into new economic system. Fish waste bio-mass are locally available resources which contain nutrients. Fermentation of the biomass produces slurries used for plankton production and plant/agri-nutri use. The waste biomass utilization is the objective of circular economy, to create environmental solution and offering products and processes to create scientific solutions for both economic and environmental solution affordable to everyone in the world (Mirabella *et al*., 2014) [30]. Producers, processors and retailers can individually have a great impact in reduction of fishery waste. Taking the holistic value chain in fishery to a complete business model eventually lead to a zero-fish waste production and consumption value chain in fisheries.

It can be concluded from the present study that ensiling fish processing waste in sugarcane molasses can be realized without any inoculation by natural fermentation at ambient temperatures in tropical and subtropical developing countries of the world. Incubation in micro aerobic condition with daily stirring two times accelerated the natural fermentation process. The products obtained like hydrolysate meals have all the macro and micronutrients suitable for bio fertilizer, feed additive and agricultural use.

Application of technology described herein would allow saving in equipment and energy when using ensiling as a potential technique to utilize fish waste in nutrient and micronutrients supplementation for agriculture and aquaculture.

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