ANALYSIS OF THE FERMENTATION PROCESS OF FISH SILAGE POWDER MADE FROM FISH WASTE AND PINEAPPLE WASTE FOR USE AS LIVESTOCK FEED: A REVIEW

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Abstract

This study was conducted to determine whether spoiled fish market scraps (viscera) from pineapple discarded, and derived products could be used as components in the production of powdered fish silage. At various phases of the production process, these repulsive components include the head, fins, fish skin, peels, seeds, viscera, and leftover flesh. Fish waste and its derivatives can be used as a supplement to animal feed because they are high in protein, minerals, and vitamins. These are also used to supplement animals' protein requirements. Fish oil and protein hydrolysates both provide significant amounts of nitrogen and phospholipids in animal feed. Fish oil and protein hydrolysates both provide significant amounts of nitrogen and phospholipids in the animal feed industry. The fermentation of sugar and other substances collected from pineapple waste could result in the production of proteins from a single cell, enzymes, organic acids, and bacterial cellulose. The powdered acid and fermented fish silage had good digestion and were an excellent source of feed, as determined by proximate analysis, amino acid composition, total antioxidant levels, DPPH-inhibition rates, and in-vitro digestibility evaluations. The in vitro digestibility of acid and fermented fish silage powders, as well as the results of proximate

analysis, amino acid composition, total antioxidants, DPPH-inhibition rates, and digestibility analyses, indicated their high digestibility and value as feed sources.
Keywords: bioactive, fermentation, FCR, silage, waste

1 INTRODUCTION

In recent years, the management of fish waste has become a major global concern. The ecology is harmed by the discharge of seafood waste. To address this issue, these discarded marine items are used to produce animal and aquaculture feed. In recent years, the management of fish waste has become a major global concern. The ecology is harmed by the discharge of seafood waste. In trying to address this issue, these discarded marine items are used to produce animal and aquaculture feed. Different little fish species or undesirable catch goods with very low market value owing to small size or any form of damage are referred to as "fish wastes." Fish wastes are any portions of a fish such as the head, skin, fins, and viscera that are not regularly used for eating. More than 50% of a fish's body is made of this type of waste [1]. Numerous causes, including population growth, growing affluence, urbanization, the growth of fishing enterprises, and new, more modern techniques for shipping industrialized, frozen fish throughout the globe, all contribute to an increase in global fish consumption. Before sale, the industry processes over 70% of the fish consumed globally. Depending on the fresh fish's weight, between 20 and 80 percent of it is processed before being sold. Following processing, between 20 and 80 percent of the fresh fish's weight is sold. The majority of the trash from fish processing is discarded in the sea and landfills, while some of these leftovers are used to make animal feed. However, a measure of the amount of protein is quite comparable to that in fish used for human food. Since fish proteins are much superior to plant-based proteins, and superior to other types of animal protein, they may be meant for a nobler application [2]. To address environmental concerns and fully utilize biomass for uses with high commercial value, better fish waste management is required. In this context, the current increase in interest in alternative applications for fish byproducts is crucial to both economic growth and sustainable development. They constitute a rich source of chemicals with added value, such as enzymes, bioactive peptides, and biopolymers, and numerous research has been conducted to examine their potential uses [8]. A metabolic process called fermentation involves drawing energy from organic components without the aid of an outside oxidizer. For this, lactic acid bacteria are used, a kind of solely fermentative, organotrophic bacteria or cocci that are aero-tolerant and generate lactic acid as the main result of fermentation. Since ancient times, fermentation has been employed as a preserving technique for all types of foods, including aquaculture feeds and livestock feeds. However, since the fermentation of fish waste increases the amounts of beneficial chemicals and also encourages a drop in anti-nutrients through hydrolysis, it is now more important for nutrition and health. Regarding hydrolysis aided by pH variations, fermentation can offer a variety of advantages.

It should be highlighted that using fermentation has several key advantages, including an increase in the efficiency of antioxidant peptides that work in tandem with glutathione (GSH) to defend against oxidative stress- related damage. Additionally, since proteins are broken down into shorter peptides and amino acids during hydrolysis throughout fermentation results in more digestible proteins, it can be a very effective method for enhancing the fishmeal's nutritional content, which is used as a source of protein in feed [24]. Assumi et al., [4] used paddy straws to smash pineapple waste (peels, crown, and pomace) at a moisture percentage of 8.7% to make an animal feed block with molasses as a binding agent (wet basis). The study also discovered that the block of animal feed made from waste pineapple was reasonably stable in storage. As a result, using pineapple waste instead of the usual green folder for animals is a desirable alternative. According to a study by Mbuza et al., [25], most farmers raise animals, including poultry. Poultries are more effective than other livestock companies at turning feed into eggs and meats.

The purpose of this article review is as an alternative solution for making animal feed and fish farming feed from fermented fish waste using pineapple waste. According to some studies, FCR efficiency and cost savings for animal feed and aquaculture were achieved by silage powder made from fish waste and pineapple waste.

2 RESULTS

2.1 Fermentation

Making fish silage is the best alternative method for utilizing fish waste because it doesn't emit any unpleasant odors while being made. The product is nutritious and can be used to feed animals. Fish silage is a liquid product made from whole or fragmented fish that has been mixed with acids, enzymes, or bacteria that produce lactic acid, causing the bulk to liquefy. The high-water content of fish silage makes it bulky and difficult to transport and store, which is a disadvantage. For ease of use, fish silage is best dried when combined with other dry ingredients or filler elements. During the co-drying process, dry ingredients are added to the wet silage after absorbing the soluble protein and some of the moisture. Co-dried fish silage for aqua feed is a simple commodity to package, store, and transport. Silage has potential applications in aquaculture and cattle due to the similarity of the protein source with the raw material and the low cost, particularly when compared to fish meal. The current study successfully converted fish market trash into powder fish silage by using inexpensive local sources of bromelain from crushed pineapple waste for lactic acid fermentation. The current work has successfully transformed fish market trash into powder fish silage for lactic acid fermentation [30].

Because it emits no unpleasant odors while being produced, making fish silage is the best alternative method for utilizing fish waste. The product is nutritious and can be used to feed animals. Fish silage is a liquid product made from whole or fragmented fish that has been mixed with acids, enzymes, or bacteria that produce lactic acid, causing the bulk to liquefy. The high-water content of fish silage makes it bulky and difficult to transport and store, which is a disadvantage.

For ease of use, fish silage is best dried when combined with other dry ingredients or filler elements. The protein level could be increased even more by reducing the amount of rice bran. The mixture of 10% and 20% rice bran may be difficult to dry due to the lower dry matter content and potential for mold growth. Given these constraints, it was determined that powdered fish silage containing 30% rice bran was preferable and was thus used for additional storage research. Palkar et al., [30] agreed with this method (***Figure. 1***). A similar observation was made by Hossain and Alam [14]. Powder fish silage can be stored at room temperature for up to three months without losing significant nutritional components.

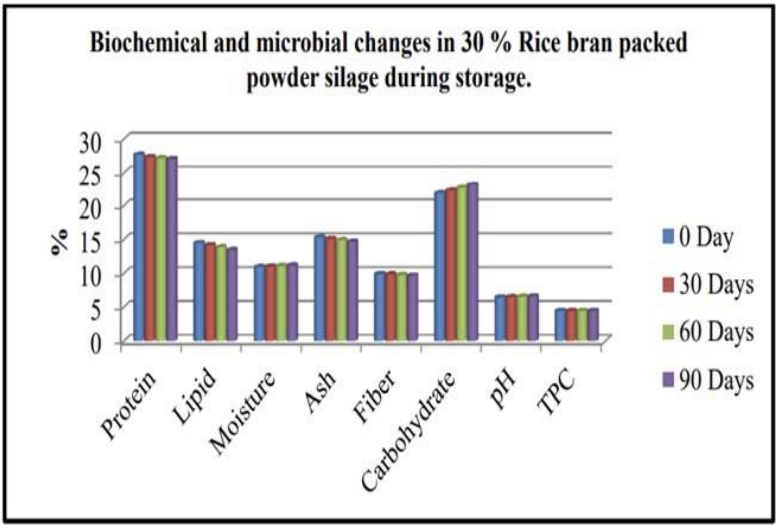

Figure 1. *Biochemical and microbial changes in 30% rice bran packed powder silage during storage (Parkar et al., 2018)*

Fish silage powder was made using biological silage that had 15% molasses. Due to its high protein content, fermented silage would be a useful source for animals in arid areas. Compared to using a fish meal, this approach is more cost-effective, eco-friendly, and safe. During the early phase of the present work, the biochemical and microbiological features of fish waste were analysed (***Table. 1***). The fish waste utilized for this project had a tolerable amount of fishy odor and its form.

Table 1. *Biochemical and microbial changes in 30 % Rice bran packed powder silage during storage*

Parameter	**Days**			
	0	**30**	**60**	**90**
Crude Protein (%)	27.66 ± 0.10	27.31 ± 0.11	27.16 ± 0.33	27.04 ± 0.06
Fat (%)	14.45± 0.11	14.16± 0.07	13.83± 0.08	13.42± 0.10
Moisture (%)	10.91± 0.14	10.99± 0.10	11.06 ±0.18	11.15± 0.10
Ash (%)	15.27± 0.11	15.07± 0.08	14.87± 0.06	14.6 ± 0.09
Fiber (%)	9.89±0.06	9.84±0.06	9.75±0.13	9.64±0.07
Carbohydrate (%)	21.82 ±0.07	22.21 ±0.08	22.64 ±0.13	23.14 ±0.11
pH	6.45± 0.05	6.48±0.09	6.53 ±0.10	6.59 ±0.14
TPC (cfu/g) (Log value)	2.10×104 (4.32)	2.15×104 (4.33)	2.25×104 (4.35)	2.36×104 (4.37)

Source: Parkar et al., (2018)

2.2 Derived products that are turned into fishmeal and fish oil

Since the aquaculture sector, which is developing quickly, is by far the biggest consumer of these goods, using by products by making fishmeal, fish protein hydrolysates, and fish oil is a side way of making healthy food available [10]. Fishmeal and fish oil prices have risen in recent years, suggesting that consumers may no longer view these items as low-quality [28]. By-products were the source of the available fishmeal in 2007, but according to previous estimates, in 2010, this percentage grew to 36% [10]. The heated raw materials are initially divided into press cake and press juice. A so-called tricanter centrifuge is then used to separate this juice into three phases: an oil phase, a solid phase, and an aqueous phase (stick water) that contains soluble nutrients. Press cake and press juice are first created from heated raw ingredients. After the aqueous phase has evaporated to a high dry matter concentration, the solid phase is subsequently added back to the press cake. The press cake is then dried to produce fishmeal. The first press cake is merely dried till it becomes fishmeal in this less expensive procedure, similar to how it is done with by-products of the tuna fishery in the Philippines and aboard certain fishing vessels. This traditional method is frequently viewed as being overly expensive. When making livestock feed, rice bran and liquid red meat silage are combined in various ratios to produce finished goods with various protein levels. This dry feed can be contained in HDPE gusseted bags that are moisture resistant.

Feed produced by mixing 1 kg of rice bran with 400 ccs of red meat silage has 20% protein, 23% fat, and 8.8% ash [11]. Since they demonstrated no negative effects on growth, blood meal and tuna by-product meal have been approved for use as formulation feeds in tilapia aquaculture. It is anticipated that the cost of feed products with various fishmeal alternatives will decrease with the usage of tuna by-product meals and blood meals as protein sources in Nile tilapia farming. Based on the fish's overall performance, BM is an appropriate protein source to substitute fish meals in young Nile tilapia. The substitution of blood meal with tuna by-product meal had a substantial impact on growth and nutrient utilization [26]. The silages are then delivered to a centralized processing facility in sufficient quantities to allow for their processing into an oil and an aqueous phase containing hydrolyzed proteins. A concentrated fish protein hydrolysate with a dry matter content of at least 42-44% is created by evaporating the aqueous phase. In the dry feed formulation for ruminants, poultry, and farmed fish other than salmon, this is coupled with oil providing long-chain omega-3 fatty acids. Using commercial enzymes, derived products from a number of the biggest slaughterhouses are treated to produce oil and hydrolysates of incredibly high grade [23].

2.3 Bioactive ingredients and nutritional makeup of pineapple waste and derived products

Bioactive components can be found in abundance in pineapple waste. The crown, peel, stem, and core make up the majority of the trash produced by pineapple. The pharmaceutical and food industries are also very interested in the phenolic substances present in pineapple leftovers because of their biological characteristics, which have health implications. Myricetin, salicylic acid, tannic acid, trans-cinnamic acid, and p-coumaric acid are a few examples, which, according to reports, are potent antioxidants, were found in a high dietary fiber powder prepared from leftover pineapple shells. However, studies have shown that pineapple waste contains polyphenols, like ferulic acid and syringic acid, which are what give the fruit its antibacterial and antioxidant benefits. Additionally, glycosides derived from these residues have numerous uses as prebiotics, bio preservatives, and food additives. In addition to bromelain, a family of proteases with numerous applications in the manufacture of food, textiles, cosmetics, and even animal feed, pineapple waste also contains insoluble fibers, pectins, sugars, protein, vitamins, minerals, and phenolic compounds. The endopeptidase bromelain, which is found in the stem and fully matured fruit, is a proteolytic enzyme that breaks down protein [15]. It is anticipated that the bromelain found in pineapple waste and byproducts will break down the protein in fish meals to increase the number of simple amino acids, Consequently, the feed conversion ratio (FCR) of animals is reduced, and livestock production is raised. Moisture (82–88%), crude protein (5–9%), crude fat (2–3%), fiber (1-6%), ash (4-6%), and carbohydrates (50–80%) make up the majority of the ingredients in pineapple peels [20], [27], [32]. The pineapple core's approximate composition is as follows: moisture content: 84.9%; crude protein: 3.6%; crude fat: 2.35%; crude fiber: 9.14%; ash: 1.7%; and carbohydrate: 83.03%2 [20]. In terms of moisture content, ash, crude fiber, crude protein, and carbs, culled pineapple has a content of roughly 83.8%, 0.45%, 0.69%, 1.19 percent, and 13.04%, successively [9], [17]. The concentrations of moisture, ash, crude fiber, crude protein, and carbs in culled pineapple are around 83.8%, 0.45%, 0.69%, 1.19 percent, and 13.04%, respectively [9], [17]. Variety, location, season, and pineapple ripeness affect the nutritional composition of pineapple trash. The relative composition of the various pineapple wastes indicates their well-shown capacity to provide value [5].

In addition, fermentation leads to the hydrolysis and degradation of proteins into shorter peptides and amino acids, it can be a very efficient way to improve the nutritional value of fishmeal, which is used as a protein source in feed [24]. Pineapple wastes have previously been utilized as supplies for the synthesis of organic acids, wine, vinegar, and yeast for the creation of food and feed proteins, as well as for the extraction of bromelain. They can also be a source of other bioactive compounds, such as antioxidants. The peel and crown of pineapple are among the waste products consisting of lignin, hemicellulose, and cellulose [33]. Using centrifugation, membrane separation, microfiltration, and ultrafiltration, they were able to recover a concentrated solution of proteolytic enzymes from the pineapple waste liquid phase in this process. The inclusion of water or solvent was avoided during the extraction process. The final enzymatic sample, which was lyophilized, exhibited comparable proteolytic activity to certain commercial preparations. The final results appeared to suggest that sugar breakdown and the production of inhibitory chemicals like furfural and hydroxymethyl furfural may be avoided. To boost the saccharification of the lignocellulosic matrix, microwave-assisted treatment was applied to the solid pineapple waste that had been removed from the liquor [7]. A rise in pineapple trash could also exacerbate the problem of insufficient garbage disposal sites and related facilities.

Bromelain enzymes from pineapple have been used as an extra element in fish and animal feed. Efforts have been made all over the world to utilize the remaining bits of fruits. Finally, the estimated feed cost might be further decreased by integrating other fruit wastes with fish waste in feed composition, however further research is needed in this area [19]. However, only about 20% of the total pineapple fruit contains juice, with the rest being discarded as garbage that pollutes the environment. This includes the crown, peeled skin, base, and core. These wastes have low protein concentrations despite being extremely rich in cellulose, hemicellulose, and other complex carbohydrates. It will also be widely used in animal feed composition, replacing pricey conventional protein sources and, naturally, lowering the cost of raising animals and animal protein [16], [35]. Additionally, it will be extensively utilized in the composition of animal feed, replacing expensive conventional protein sources and, naturally, bringing down the price of rearing animals and animal protein [16], [35]. By producing secure and nutrient-dense animal diets, it is crucial to make the most of waste products from the agricultural and food processing industries, such as pineapple peels. This is because there is a rising demand for innovative protein sources [3].

2.4 Feeding Livestock

The possibility of using pineapple waste for animal feed has been mentioned in research [6], [21], [29]. However, only 20% of the waste from pineapple production in Uganda is being utilized as animal feed [38]. Given the high moisture content, pineapple waste in the flesh is quite prone to degradation. The situation is improved by turning pineapple waste into shelf-stable animal feed [6]. Waste from pineapples like the stem and leaves may be processed into pellets for use by domestic birds and animals [6], [36], [35]. Because pineapple waste has a lot of fiber, it can provide energy and facilitate animal and avian digestion [6]. Gowda et al. [12] produced silage from the crown and peels of pineapples in a ratio of 4:1. According to the study, using PFR effectively increased cattle's daily milk production on average without harming their diet or general health. Research by Hattakum et al. [13] found that using pineapple stem silage significantly reduced the cost of feeding cattle [22] also looked at how different bagasse-vinasse combinations with pineapple peel silage and sweet corn husk and cob silage affected the daily body weight of animals. According to the study, Animals fed the bagasse-vinasse mixture with pineapple saw a weight gain that was much higher than those fed the other two mixtures. The feed block is an alternative animal feed that must be created. Forage, concentrate, and other nutrients are included in the feed block in the proper amounts to suit the animal's nutritional requirements [18], [34].

2.5 Feed conversion efficiency and waste disposal

Food wastes may be used as animal feed, solving issues with waste management and food security while reducing the need for conventional feed production, which is a resource and environment intensive. When analyzing the use of food waste in animal feed, factors such as the nutritional value of the wastes, the techniques used to treat them, and the growth performance of the animals fed these waste-based diets were all taken into account. Rajeh et al. [31] identified optimal levels of food loss/food waste inclusion as well as associated FCR values, as well as nutritional qualities such as dry matter (DM), crude protein (CP), ether extract (EE), nitrogen-free extract (NFE), and crude fiber (CF) (2020). Note that only studies reporting the approximate compositions of the tested food waste before creating experimental diets and before combining it with other feed ingredients are included in this section (***Table. 2***).

It should be made clear that the research in this section only examines the rough compositions of the food waste that was the subject of the study before experimental diets were made and before it was combined with other feed additives. Rajeh et al., [31], the nutritional profile of food waste may also alter as a result of waste processing techniques. For instance, fermentation at 60-80 °C for 4–10 led to nutritional loss when compared to rotating disk drying food waste at 120 °C for 30 minutes. However, using either of the aforementioned methods, the waste-based feed that was created had an adequate quantity of nutrients for feeding animals. However, the level of nutritional difference between waste-based feeds that have undergone heat treatment and those that have undergone fermentation may not be a crucial factor in selecting a waste treatment technique. The decision is mostly based on variations in feed stability and safety brought on by different treatment techniques. It would be necessary to accurately characterize food waste variability and cross-examine nutritional profiles across various food waste treatment techniques to incorporate food waste into commercial animal diets.

Food waste is frequently given to ruminants and poultry in impoverished countries in their natural state. It is technically more difficult since fish feeds must be treated to enhance the nutrient profile and water stability. The nutritional composition of food waste must always be assessed batch by batch and changed before being given to cattle in industrial farms. Technically, it is more difficult. The feed mixture was stabilized and given a longer shelf life thanks to ensiling, which entails adding microbial or yeast agents after heating or sterilizing food waste. One research, for instance, described using probiotics to aerobically ferment kitchen waste for 24 hours at 30 to 40 °C before delivering the completed product to farms to feed livestock. The percentage of food waste used to replace conventional materials in commercial animal diets varies from 10% to 100%. Varied quantities of food waste were replaced for commercial diets to produce various FCR values, which are calculated as the feed intake to weight growth. Lowest reported FCR values for various amounts of replacement in each experiment, such as those that achieved the best animal growth performance, correlate to the optimal food waste inclusion levels. Animal growth performance in response to various degrees of food waste replacement was affected by the source and quality of the waste materials under study, the species and age of the animals, and the duration of the feeding trials. Diets for Nile tilapia should contain no more than 20% to 25% food waste, yielding FCR values of 1.5 to 1.1. Restaurant food waste with FCR values between 3.0 and 5.6 may replace 20 to 50 percent of the feed for commercial shepherds [31].

Table 2. *Major nutritional attributes of food loss/waste samples used in animal feed, optimum loss/waste inclusion level, and FCR values, as reported in the literature*

Country	Tested animal	DM%		CP%		EE%		NFE%		CF %	FCR
		Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	
Japan	Fish	97.9	–	19.6	11.3	8.2	–	–	–	–	1.5
Lebanon		93.7	0.6	18.9	2.1	22.2	21.6	31.8	–	15.3	2.03
Lebanon		93.7	0.6	18.9	2.1	22.2	21.6	31.8	–	15.3	1.1
Nigeria		91.5	–	12.7	–	24.0	–	80.5	–	2.0	0.9
Brazil		89.8	–	14.3	–	2.6	–	81.5	–	0.3	2.5
Tunisia		92.9	–	2.4	–	0.3	–	85.5	–	2.1	1.8
China		93.2	0.1	31.1	10.8	13.3	13.6	–	–	5.7	2.6
Kingdom of Saudi Arabia		86.7	1.3	2.6	5.7	0.3	13.8	79.7	–	1.8	1.2
Iraq		91.1	–	24.0	–	7.8	–	–	–	0.8	3.1
Nigeria	Chicken	89.3	–	5.3	–	11.0	–	81.7	–	1.1	2.5
Malaysia		89.3	1.3	16.0	1.2	7.1	1.0	–	–	3.7	3.5
South Korea		93.7	–	20.6	–	10.0	–	–	–	8.9	3.3
Taiwan		87.6	2.4	15.8	3.4	16.0	3.2	–	–	10.8	3.9
Iran		92.0	–	12.6	–	4.1	–	–	–	2.6	1.9
India		–	–	6.9	–	1.9	–	–	–	–	2.0
Czech Republic		95.2	–	8.1	–	1.8	–	–	–	9.1	2.3

Country	Tested animal	DM%		CP%		EE%		NFE%		CF %	FCR
		Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	
Nigeria		94.7	–	8.8	–	16.4	–	61.3	–	1.5	1.9
Brazil		–	–	12.9	–	8.6	–	–	–	8.7	3.0
Japan		82.1	–	15.8	–	–	–	–	–	2.0	4.6
US		93.1	–	8.3	–	13.7	–	–	–	0.9	2.3
South Korea	Cows	85.3	1.5	20.1	6.0	9.1	16.8	–	–	9.7	7.3
US		94.5	0.04	20.0	2.6	7.6	0.1	–	–	–	ADG 0.7 kg/d
US		46.1	20.8	29.4	24.6	15.8	20.5	–	–	–	ADG 1.2 kg/d
Uganda	Goats	28.7	0.8	8.3	0.5	–	–	42.0	1.26	–	33.5

Source: Rajeh et al. [31]

3 CONCLUSIONS

Both pineapple and fish waste can be used to produce fish silage powder. Enzymes, single-cell proteins, bacterial cellulose, and organic acids may be produced as a result of the fermentation of the sugars and other nutrients extracted from pineapple waste. The in-vitro digestibility of acid and fermented fish silage powders, as well as the results of proximate analysis, amino acid composition, total antioxidants, DPPH-inhibition rates, and digestibility analyses, demonstrated their high digestibility and value as feed sources. It must also be recognized. The formulation of these two wastes can be used to make both animal feed and aquaculture feed. Using these two wastes serves two functions: it reduces waste and livestock feed costs

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