



## Literature review on fermentation factors of restaurant organic waste affecting feed quality

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### ABSTRACT

The high level of public consumption, balanced with the increasingly dense population globally, makes food waste more and more. Food waste is the second-largest contributor to waste in the world. Moreover, the lack of food waste management makes this condition even worse. This food waste can be found, one of which is in restaurants, school canteens, food courts, and others. Fermentation is the process of breaking down complex substances into simpler ones. A fermentation process can help process food waste into various products such as liquid organic fertilizer, compost, biogas, and raw material for fish feed. Through the fermentation process, food waste can be used as an alternative fish feed with high nutritional content to benefit fish cultivators. Fish need many nutrients for their bodies, with food waste that has been processed will meet the dietary needs of fish. The cultivators will benefit more from the cost of feed and the sale of fish that can meet consumer needs. Moreover, the demand for the fish market is increasing every year. Several factors play a role in the success of the food waste fermentation process and the quality of the resulting product to be converted into fish feed raw materials. These factors include incubation time, pH acidity, and microbial factors that can accelerate the spoilage of fish feed raw materials.

### Preliminary

The increase in fish consumption is due to the current high protein requirement of the community. This has caused many people to start cultivating fish both on a small and large scale. The increasing number of fish farming makes fish farmers need large amounts of feed so that the quality of the fish is getting better. The feed factor determines the production cost reaches 60%-70% in fish farming, so it needs effective and efficient management (Handajani, 2012). However, the high cost of commercial fish feed makes fish farmers look for alternative ways to reduce cultivation costs (Achadri *et al.*, 2018). According to Djunaidah (2017) several factors cause the low consumption of fish in Indonesia. First, the lack of infrastructure needed to distribute high-quality fish to consumers, including modern and supportive market infrastructure, minimal ice stocks, or lack of refrigeration on board.

The life span of fresh fish tends to be short, so fish processing from the ship to the consumer must be carried out adequately with a compelling value chain. Otherwise, the quality of fish will decrease, and fish consumption will be affected.

Second, several types of high-quality seafood such as tuna, shrimp, crab, octopus, and cuttlefish are sold more in the international market. This contributes to the low consumption of high-quality seafood in Indonesia. Local consumers are more likely to find seafood of medium or low quality.

Third, people tend to prefer meat over fish. In an agrarian society, beef, chicken, eggs, and milk are preferred over fish. Fish protein is higher (52.7%) than beef (19.6%) and eggs and dairy products (23.2%).

The food industry is a sector that can be developed along with the increasing human population in the world. One sector of the food

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industry is restaurants. Food waste accounts for the second-largest waste after construction due to the increasingly rapid global economic development and rapid population growth (Dai et al., 2012). The proliferation of the restaurant industry causes the production of restaurant waste to increase. Food waste is food residue that is no longer consumed by humans and is disposed of for certain reasons (Wulandari, 2019). Restaurant waste that is not managed will cause environmental pollution. Restaurant waste generally comes from the production site or kitchen. The lack of handling of restaurant waste makes some people process it into alternative fish feed to reduce the use of commercial feed. However, to improve its nutritional quality, restaurant waste can be fermented before being used as fish feed. Third, people tend to prefer meat over fish. In an agrarian society, beef, chicken, eggs, and milk are preferred over fish. Fish protein is higher (52.7%) than beef (19.6%) and eggs and dairy products (23.2%).

According to Pamungkas (2011) that fermentation is breaking down organic compounds into simpler compounds by involving microorganisms. The fermentation process can increase and improve fish feed raw materials (Andriani et al., 2020). Bacteria in the use of fermentative materials have a role in converting proteins into amino acids. The presence of bacteria in the fermentation process will produce enzymes that can decompose complex compounds into simple compounds to be easily digested by fish (Anasih et al., 2021). The availability of food waste is considered abundant and has not been widely used to support fish cultivation (Ramadhan et al., 2015).

### Characteristics of Food Waste

Waste or garbage is divided into two, namely organic and inorganic. The difference lies in the length of the decay process. Organic waste can quickly decompose, while inorganic waste is difficult to decompose (Fordian et al., 2017). Restaurant waste is one part of food waste. Most of the food waste is produced by population activities, food processing, fast food, etc. Restaurant waste is organic waste with biodegradable properties (Andriani et al., 2020).

Qing et al. (2019) said that several methods of processing food waste include composting and fermentation to manufacture environmentally friendly raw materials. However, if it is only for composting, small profits will be (Diener et al., 2011). It is necessary to maximize recycling, minimize waste, streamline consumption, and ensure that a product can be recycled to generate less waste (Fitriyani et al., 2014). Food waste or leftovers are a cheap and helpful source of feed in the fishing industry (Wing et al., 2019). Restaurant waste contains content that can be used as a source of fish feed, but this waste needs to be processed first (Andriani et al., 2021). In addition to the need for processing, restaurant waste is low in protein and has a rough fiber that cannot affect fish growth (Achardi et al., 2018). Apart from being used as raw material for fish feed, organic restaurant waste can also be fermented for the manufacture of organic liquid fertilizer (Nur et al., 2015).

One of the alternative feed ingredients for protein sources of vegetable origin is vegetable waste and food scraps, while animal protein sources are waste derived from the remains of meat, chicken, fish, and bones. Several studies have been conducted to determine the nutritional content of restaurant waste, it was presented in Table 1.

Table 1. Nutrient Content of Restaurant Waste

The nutritional content of restaurant waste				Reference
	Protein	Fat	Crude fiber	
1	10.70%	9.12%	9.45%	Achadri et al. (2018)
2	15.40%	7.99%	4.99%	Sandra et al. (2019)
3	22.40%	13.56%	4.98%	Cahya et al. (2019)
4	17,29%	8,73%	8,09%	Setiawan (2009)
5	18.58%	8.77%	4.78%	Andriani et al. (2021)
6	10,89%	9,70%	9,13%	Dughitta et al. (2018)
7	26,00%	16,2%	5.22%	Sin Ho et al. (2018)
8	27,50%	28,8%	2,30%	Garcia et al. (2005)

One of the factors that influence growth is protein. Optimum protein requirements for fish vary depending on water temperature, feed consumption, fish species, life stage, daily feeding amount, protein

quality (amino acid composition), feeding frequency, and non-protein energy quality (Beruatjaan et al., 2012). Fat is a source of energy. Fat or lipid is one of the nutrients needed by the body because it provides

a power of 9 kilocalories/gram, dissolves vitamins A, D, E, K, and can provide essential fatty acids for the human body (Angelia, 2016). than carbohydrates and proteins. However, because the ability of fish to consume protein is extraordinary, the performance of fat as an energy source occupies the second position after protein (Gunawan and Munawar, 2015). The natural fiber is the part of carbohydrates that cannot be digested, consisting of cellulose, hemicellulose, lignin, and polysaccharides (Andriani et al., 2021). When crude fiber is at a low value (>10 percent), it will follow a decrease in digestibility, decreased absorption, increased metabolic waste, and reduced aquaculture water quality (Iskandar and Fitriadi., 2017). The higher the crude fiber, the lower the carbohydrate digestibility.

### Fermentation and Affecting Factors

The process of decomposition of the substrate by microbial activity both aerobically and anaerobically is called fermentation (Astuti et al., 2013). The difference between aerobic and anaerobic fermentation is that aerobic fermentation uses air or oxygen in fermentation. While anaerobic fermentation does not use air or oxygen in the fermentation process. The products produced from the anaerobic fermentation process are carbon dioxide (CO<sub>2</sub>), water (H<sub>2</sub>O), acetate, ethanol, volatile acids, alcohol, and esters (Atmojo, 2017).

The fermentation process carried out in the manufacture of fish feed can reduce the fiber value raw material for fish feed, namely food waste. In addition, fermentation can improve protein quality (Putra et al., 2020), increase digestibility, and add aroma and taste to feed (Andriani et al., 2020). The fermentation process uses microbial fungi, yeasts, and bacteria (Karlina et al., 2013). In the restaurant waste fermentation process, bacteria will produce

enzymes that increase the nutritional value of fish feed ingredients (Ardiansyah et al., 2018). A total of 500 grams of restaurant waste is used in the fermentation process. The waste is collected, then dried, and analyzed using a proximate test to determine the nutrient content for fish feed raw materials (Andriani et al., 2021). Fermentation aims to improve the quality of feed ingredients to improve fish growth by increasing feed digestibility. Changes in nutritional value can be seen in the test results of feed ingredients before and after fermentation.

### Factors That Cause The Fermentation Process In Waste

#### a. Fermentation time

The duration of fermentation is influenced by factors that directly or indirectly affect the fermentation process. The length of fermentation of restaurant waste has an effect on the decay process of restaurant waste. The size of incubation time affects the decrease in pH and increase in the total concentration of fermented effluent acid (Table 2).

#### b. Microorganisms used

The addition of probiotics consisting of several types of microorganisms can accelerate the fermentation process. One of the microorganisms that play a role in increasing the protein content is Bacillus sp. In addition to these two types of microbes, it turns out that the part of Saccharomyces cerevisiae has an effect in simplifying compounds in fermented feed ingredients during biochemical processes because it acts as a biocatalyst (Wing et al., 2019). The use of various types of microbes that ferment restaurant organic waste is presented in Table 3.

Table 2. Effect of Restaurant Waste Fermentation Time.

No	Fermentasi Time	Substrat Variety	Result	Reference
1	15 days	Restaurant organic waste	Fermentation lasted for 15 days showed better results by 22.30% protein.	(Rajeh et al., 2020)
2	14-28 days	Restaurant organic waste	The Tukey Post-hoc pairwise comparison test also proved a similar effect exerted by 14-28 days of fermentation period on this protein content has increased by about 50% compared to unfemented or fermented for 7 days, i.e., 0.32-0.34 mg against 0.22-0.25 m	(Djamalu et al., 2019)
3	14 days	Restaurant organic waste	Optimum protein content that has been fermented for 14 days with 0.5% by weight of powdered bacterial consortium produces at least 25% higher protein content.	(Andriani et al., 2021)

Table 3. Types of Microbes in Restaurant Waste Fermentation

No	Microbes Variety	Substrat Variety	Result	Reference
1	<i>Lactobacillus casei</i> , <i>Saccharomyces cerevisiae</i> and <i>Rhodospseudomonas palustris</i>	Restaurant organic waste	Fermented organic waste into animal feed ingredients with a protein content of 22.40%. The fish feed pellets produced are suitable feed for catfish.	(Achardi et al., 2018)
2	Consists of bacteria <i>Bacillus sp.</i> <i>Lactobacillus sp</i> and yeast	Restaurant organic waste	The addition of 8% probiotics improved the nutritional quality of restaurant waste, which was fermented into animal feed ingredients with a protein content of 50.83%.	(Nasser et al., 2018)
3	<i>Clostridium sp.</i> and <i>Bacillus sp.</i>	Restaurant organic waste	The addition of 0.5% bacterial consortium powder resulted in at least 25% higher protein content.	(Andriani et al., 2021)
4.	Probiotics consisting of three types of microorganisms ( <i>Bifidobacterium bifidum</i> ., <i>Bifidobacterium breve</i> , <i>Bifidobacterium infantis</i> )	Restaurant organic waste	The fermentation of restaurant waste into animal feed showed a better yield of 23.50% protein than the fermentation of <i>Lemma sp.</i>	(Andriani et al., 2021)

### c. Degree of acidity or pH

The degree of acidity (pH) is closely related to the number of microbes. This decrease in pH to acid will interfere with the activity of bacteria that have an optimum pH of 6-8, namely bacillus bacteria, spoilage bacteria and other pathogens, because this decrease in pH will produce high amounts of

protons, resulting in enzyme denaturation (Soedibya 2013).

The optimum degree of acidity for the fermentation process is 4-5, if it is below 3 then the speed of the fermentation process will decrease (Yumas et al., 2014). The pH value in the fermentation of restaurant organic waste is presented in Table 4.

Table 4. pH Value in Restaurant Organic Waste Fermentation

No	pH value	Substrat Variety	Result	Reference
1	pH 4 – pH 7	Restaurant organic waste	Decreasing the pH from pH 7 and decreasing to pH 4 after 4 weeks during the fermentation process, bacteria of the genus Bacillus, Lactobacillus, and Acetobacter will produce various enzymes that improve the nutritional quality of animal feed ingredients..	(Suprpto et al., 2017)
2	pH 5 – pH 6	Restaurant organic waste	Restaurant waste fermentation into animal feed ingredients at pH 5 – pH 6 showed better results by 24.50%	(Hamdiani et al., 2018)
3	pH 4 – pH 5	Restaurant organic waste	The decrease from pH 4 – pH 5 after 2 weeks during the fermentation process, Bacillus and Lactobacillus bacteria increased the nutritional quality of animal feed ingredients by 20.3%	(Suari et al., 2019)

### d. Dose

The use of probiotics in the fermentation process helps break down compounds or ingredients from feed that are not consumed and cannot be digested by fish. Compounds that cannot be digested will be converted by probiotics from complex forms into simpler forms due to enzymes produced by these probiotics (Dughita et al., 2018). The use of probiotics must be by the application instructions

and depending on the designation (Garcia et al., 2005).

According to research conducted by Yulianingrum et al. (2017), there was an effect of giving probiotics with different doses or amounts. The addition of probiotics as much as 6 ml/kg of feed, which was the highest dose used, showed more optimal results on the growth of African catfish (*Clarias gariepinus*) compared to no addition of

probiotics and the addition of probiotics of 2 ml/kg and 4 ml/kg. The use of probiotics in this amount resulted in 35.22% protein content, 2.38% fat, and 2.46% crude fiber. Research conducted by

Yulianingrum et al. (2017) is also supported by other studies which show the effect of probiotic dosage on nutrient levels in feed. The studies are presented in Table 5.

Table 5. Effect of Probiotic Dosage on Feed Nutrient Levels.

No	Ingredients	Result	Reference
1	Restaurant waste	8% probiotics to the feed increased protein by 50.83% and decreased crude fiber by 30.74%.	(Sandra, 2019)
2	Restaurant waste	The addition of 0.5% bacterial consortium powder resulted in at least 25% higher protein content.	(Andriani et al., 2021)

### e. Temperature

Temperature is one of the abiotic aspects that has an essential role in the fermentation process of feed for fish. Temperature is needed in optimal conditions to be able to support the growth and development of microorganisms (Yanuarto et al., 2019). That selecting the right temperature in the bioconversion process will effect the performance of the enzymes and microorganisms (probiotic) used. For example,

mold microorganisms will grow more optimally at room temperature (25-30oC) so that when placed at low temperatures, they will not have good performance. *Aspergillus* sp. generally also prefers to grow at high temperatures, namely > 30oC, so that this temperature is said to be the optimal temperature for the activity of *Aspergillus* sp. (Rosidine et al., 2012). The effect of temperature on nutrient levels in feed is presented in Table 6.

Table 6. Effect of Fermentation Temperature on Feed Nutrient Content.

No	Ingredients	Microbes Variety	Result	Reference
1	Silage of frozen frog processing waste	Proteolytic	An increase in temperature of 10 °C significantly affected the nutrient levels of the feed. A temperature of 40 °C produces a protein content of 41.05%; fat 7.53%; and 12.81 % fiber. While the temperature of 50 °C has a protein content of 44, 14 %; 7.93 % fat, and 12.42 % fiber.	(Rosidin et al., 2012)
2	Palm Mud	<i>Aspergillus niger</i>	The temperature of 28 °C showed the value of crude protein was 23.2% and crude fiber was 1.8 %. While the temperature of 32 °C showed the natural protein value of 24.7 % and 18.6 % for oil fiber.	(Sinurat, 1998)

### Nutritional Quality of Fermentation Products

Waste fermentation has been widely used for the manufacture of fish feed. Based on the data that has been used as a reference, fermentation is carried out for fish feed by using probiotics. The probiotic technique is one of the probiotics that can be used as the primary precursor in feed fermentation and maintain healthy pond water (Subandriyo et al., 2012). Making probiotics takes a minimum of months to ripen and to make fermented feed.

The process of fermenting fish feed has been widely carried out by catfish, milkfish, and gourami breeders. This is due to the spike in prices for ready-made fish feed, so alternative meals are needed to save livestock costs. Restaurant waste, which

generally cannot be consumed by humans, can be reprocessed into alternative fish feed, considering its rich in nutritional content. Processing requires the role of probiotics or microorganisms to break down complex compounds such as fiber into simpler organic compounds so that their digestibility is better. In addition, fermentation can also increase the nutrients needed by fish, such as protein, fat, and others (Table 7). Through the fermentation process in restaurant waste, fish feed needs will be met. This process also plays a role in reducing the current destruction so that waste does not accumulate and is wasted, and the environment is not polluted; it is necessary to cure for at least 6 days.



Table 7. Effect of Addition of Restaurant Waste Fermentation in Fish Feed.

No	Ingredients	Microbes Variety	Result	Reference
1	Restaurant waste	<i>(Lactobacillus sp., Bacillus sp., Saccharomyces cereviceae)</i>	Increase protein by 50.78 % and decrease crude fiber by 30.74 %.	(Sandra, 2019)
2	Restaurant waste	Bread yeast	Increase protein content by about 50 % compared to unfermented or fermented for 14-28 days	(Cahya, 2019)
3	Restaurant waste	<i>Cellulotic microorganism</i>	The addition of 0.7 % bacterial consortium powder resulted in at least 35 % higher protein content.	(Andriani et al., 2021)

## Conclusion

Restaurant waste can be used as raw material for making fish feed through a fermentation process. However, in the manufacturing process, some factors can affect the quality of fish feed products. These factors include the length of incubation, the type of microorganism used, the degree of acidity or pH, temperature, and dosage.

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