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POTENTIAL UTILIZATION OF CASSAVA PEEL WASTE FOR FISH FEED

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ABSTRACT

This manuscript provides a comprehensive review of the potential and utilization of cassava peel as a fish feed ingredient. Agro-industrial activities in Indonesia generate substantial waste, including cassava peel, which can serve as a valuable carbohydrate source in fish feed. Cassava is the third most important food crop commodity in Indonesia, and its productivity has been increasing over the years. Cassava possesses a good nutritional profile, with high starch content and energy value. Fermentation of cassava peel can enhance its nutritional value by increasing crude protein content and reducing anti-nutrients such as cyanide acid. Fermented cassava peel products have been shown to reduce reliance on imported feed ingredients and lower production costs without compromising fish growth. The utilization of fermented cassava peel waste presents a sustainable solution for converting agro-industrial waste into a suitable fish feed ingredient.

INTRODUCTION

Agro-industrial activities, encompassing agriculture, plantations, and fisheries, are wide spread throughout Indonesia, generating substantial amounts of waste that hold potential as fish feed ingredients. Among the abundant agricultural and food processing industry wastes is cassava tuber skin. Cassava, following rice and corn, is the third most important food crop commodity in Indonesia. In 2015, the harvested area of cassava in Indonesia was 0.95 million hectares, yielding a production of 21.80 million tons with a productivity rate of 22.95 tons per hectare. Projections for 2016 estimate a harvested area of 1.11 million hectares and a productivity of 20.23 tons per hectare, indicating an expected national cassava production of 25 million tons.

The development of cassava productivity in Indonesia from 1980 to 2016 exhibited an upward trend, with an average annual growth rate of 2.64%. Productivity increased from 97.51 kg/ha in 1980 to 239.13 kg/ha in 2016. Moreover, in the past five years, productivity growth has accelerated, reaching 2.85%. The three main cassava-producing provinces, namely Lampung (27.71%), East Java (14.80%), and Central Java (14.59%), contributed significantly to the average harvested area of cassava from 2011 to 2016, accounting for 57.10% (BKP Ministry of Agriculture, 2014). As national cassava productivity continues to rise, there is a subsequent increase in waste production, including cassava peel, which can serve as a valuable carbohydrate source in fish feed. This paper presents a comprehensive literature review on the potential and utilization of cassava peel as fish feed.

BIOLOGY AND NUTRITIONAL VALUE OF CASSAVA

Cassava plants can be classified based on the results of plant identification as follows:

Kingdom : Plantae

Division : Spermatophyta

Subdivision : Angiospermae

Class : Dicotyledoneae

Order : Euphorbiales

Family : Euphorbiaceae

Genus : Manihot

Species : *Manihot esculenta*

Figure 1 **The appearance of cassava plants**

Cassava is a highly valuable food ingredient, particularly as a source of carbohydrates, and possesses a reasonably good nutritional profile. The tubers of cassava consist of approximately 60% water and 25% to 35% starch, along with proteins, minerals, fiber, calcium, and phosphate. In terms of energy content, cassava ranks higher than rice, corn, sweet potatoes, and sorghum. The nutritional composition of cassava varies across its different parts, as illustrated in Table 1.

***Table 1*. Nutritional Content of Cassava in Each Part**

Nutrition	Leave (%)	Stem (%)	Tuber (%)	Skin (%)
Crude Protein	23.2	10.9	1.7	4.8
Crude fiber	21.9	22.6	3.2	21.2
Ether extract	4.8	9.7	0.8	1.22
Ash	7.8	8.9	2.2	4.2
Nitrogen free extract	42.2	47.9	92.1	68
Ca	0.972	0.312	0.091	0.36
P	0.576	0.341	0.121	0.112
Mg	0.451	0.452	0.012	0.227

FERMENTATION TO ENHANCE THE NUTRITIONAL VALUE OF CASSAVA PEEL

Fermentation is a widely employed, simple technology for processing agro-industrial waste, including cassava peels, to improve their nutritional quality. Numerous fermented products derived from agro-industrial waste have been investigated and continue to be explored to support feed self-sufficiency in the aquaculture industry. Fermented cassava peel products generally exhibit an increased crude protein content due to the enrichment of microbial proteins. The protein content in fermented products can reach 20% to 100% higher than their initial values. Fermentation also facilitates a reduction in crude fiber and anti-nutrients present in agro-industrial waste, thereby transforming it into a more digestible feed ingredient for fish. Cassava contains naturally occurring anti-nutrients in the form of cyanide acid (HCN), which is toxic when consumed. Cyanide acid in cassava is produced from cyanogenic glucoside compounds, commonly known as linamarin (Figure 2). Through the fermentation process, the cyanide acid present in cassava peels and leaves, in the form of hydrolyzed glycoside bonds, is broken down into glucose, acetone, and HCN.

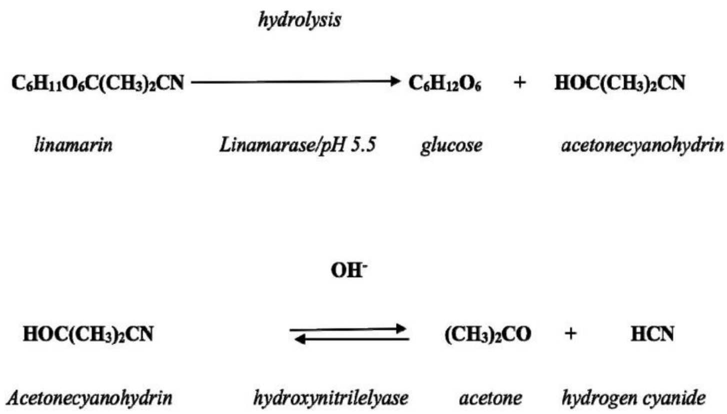

***Figure 2*. Cyanide Formation Reaction (Chiemela *et al.*, 2020)**

Several studies have demonstrated the effectiveness of fermentation in reducing cyanide acid levels and increasing the nutritional value of cassava waste. Hermanto and Fitriani (2019) reported a 100 percent reduction in cyanide content in bitter cassava through fermentation using Rhizopus oryzae. Another study found that a 4-day fermentation period with the addition of 0.5% tape yeast reduced cyanide acid levels in cassava skin from 231 mg/kg to 0.47 mg/kg, representing a decrease of 99.89%. Similarly, cyanide acid levels in cassava leaves decreased from 183 mg/kg to 0.46 mg/kg, a decrease of 99.74%. Additionally, protein levels increased significantly, with cassava skin showing an increase from 4.58% to 10.26% (124.02% increase), and cassava leaves exhibiting an increase from 8.30% to 9.57% (15.30% increase) (Hermanto *et al.*, 2017).

However, as a standalone feed ingredient, fermented cassava waste has limitations in terms of micro-protein content, particularly the low levels of essential amino acids lysine and methionine, which are crucial for fish growth. Therefore, the application of fermented products in fish feed formulations should involve the inclusion of commercial feed ingredients or other feed components to ensure nutritional requirements are met.

UTILIZATION OF CASSAVA PEEL WASTE AS A FISH FEED RAW MATERIAL

The utilization of fermented cassava peel waste has proven to be effective in reducing the dependence on imported feed ingredients in fish feed without compromising fish growth. Research evaluations suggest that local feed ingredients can be included in feed formulations at levels ranging from 5% to 30% for vegetable sources and up to 40% for animal sources. Compared to commercial feeds containing 70% imported ingredients, the utilization of fermented products significantly reduces reliance on imports and lowers production costs. Moreover, fermented products provide a viable solution for the potential environmental pollution resulting from agro-industrial waste by converting it into a suitable and sustainable fish feed ingredient (Table 2).

Table 2. **Performance of Fish Fed with Cassava Peel Waste**

Treatments	Results	References
The feeding of cassava peel waste at different doses, namely A (5%), B (10%), and C (15%)	Treatment B (10% dose) demonstrated the most favorable growth performance in carp seeds, exhibiting an absolute length growth of 0.68 cm and an absolute weight growth of 0.64 grams. Conversely, treatment A (5% dose) exhibited the highest survival rate, with 84.44% of the carp seeds successfully surviving the feeding period.	(Ali *et al.*, 2020)
Comparing the feeding of unfermented cassava peel waste and fermented cassava peel waste	The results revealed that the fermented feed treatment yielded superior outcomes in terms of absolute weight growth, absolute length growth, tilapia daily growth rate, and feed conversion ratio, with values of 2.5 grams, 1.7 centimeters, 1.62%, and 1.91, respectively. On the other hand,	(Nurhayati *et al.*, 2018)

	the non-fermented treatment exhibited the highest survival rate, with an impressive value of 95%.	
The treatment involved using fish feed supplemented with soybean meal and fermented cassava peel. The fermentation process employed a mixed culture of bacteria, including *Lactobacillus plantarum* and *Leuconostoc mesenteroides*, as well as yeast strains such as *Saccharomyces cerevisiae* and *Schizosaccharomyces pombe*.	During the 3-day fermentation period, the microbial population exhibited an increase through microbial succession. As a result, the crude protein content of the fermented cassava peel rose from an initial value of 5.4% to 17.2%. The decrease in pH from 7.2 to 3.4 promoted the growth of lactic acid bacteria, thereby inhibiting proteolysis. In terms of fish growth, the specific growth rate appeared to decline as the feeding trial progressed. However, over the 8-week study period, the fish exhibited a weight increase of 70% and 50% when fed with fermented soy and cassava peels, respectively, compared to a 60% increase in the control group fed with fish feed alone. Although the growth performance results indicated that the fish performed slightly better on soybean meal, the observed differences among the treatments were not statistically significant ($p>0.05$).	(Ubalua and Ezeronye, 2008)
The feeding trial for tilapia lasted for 45 days and included three treatments: a reference feed, unfermented cassava peel flour feed, and *A. niger* fermented cassava peel flour feed.	The daily growth rate of tilapia fed with fermented cassava peel flour was 1.32% per day, which was significantly higher ($P<0.05$) compared to the growth rate of tilapia fed with unfermented cassava peel flour, which was 0.72% per day. Additionally, the digestibility value of the fermented cassava peel flour feed (48.73%) was higher than that of the unfermented cassava peel flour feed (11.74%).	(Putra *et al.*, 2022)

Conclusion

In conclusion, cassava peel waste holds significant potential as a fish feed ingredient, and fermentation is an effective method for enhancing its nutritional value. The utilization of fermented cassava peel waste in fish feed formulations reduces reliance on imported ingredients and lowers production costs, making it economically viable. The fermentation process reduces anti-nutrients, such as cyanide acid, and increases crude protein content, improving the digestibility and nutritional quality of cassava peel waste. However, as a standalone feed ingredient, fermented cassava peel waste may have limitations in terms of micro-protein content, particularly essential amino acids. Therefore, it is recommended to formulate fish feeds with a combination of fermented cassava peel waste, commercial feed ingredients, and other feed components to ensure balanced nutrition for optimal fish growth. The utilization of cassava peel waste as a fish feed raw material provides a sustainable approach for reducing waste and promoting self-sufficiency in the aquaculture industry. Further research and development are warranted to explore the full potential and optimize the utilization of cassava peel waste in fish feed formulations.

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