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Chemically Treated Chicken Feather Meal for Fish Feed

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

The increasing demand and consumption of chicken meat from year to year makes the waste produced also increase, especially chicken feathers. One of the physical waste utilization of chicken feathers is handicrafts that use chicken feathers such as dream catchers. The utilization of chicken feather waste as a feed ingredient is still relatively rare because chicken feathers have crude protein which includes structural protein called keratin. Therefore, it is necessary to process it first so that the keratin in the chicken feather can be degraded properly. The purpose of this review is to provide an overview of the chemical processing of chicken feathers and its application as one of the raw materials that make up fish feed. Based on the results of the review of published articles, chicken feathers contain protein and amino acids that are quite good as fish feed. Chemical processing of chicken feathers is considered more effective and economical because it does not damage the protein in chicken feathers and produces more natural chicken feather flour and can reduce damaged amino acids. The quality of chicken feathers is influenced by chemicals, concentration and length of processing time. Various fish species such as tilapia, catfish and catfish show good growth and survival when fed feed containing chicken feather meal. In

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other words, chicken feather meal has the potential to be used as an alternative raw material in making fish feed.

Keywords: Chicken feather; chemistry; growth; processing.

1. INTRODUCTION

Chicken feathers are waste from chicken slaughterhouses. Along with the increasing chicken population and slaughter rate, chicken feather waste continues to grow from year to year. The potential availability of chicken feathers from slaughterhouse waste in Indonesia is around 4-5% of live weight. Broiler production per year reaches 2 billion birds with an average harvest weight of 1.5 kg/head. From this, it can be estimated that the total broiler feather waste reaches 120.00 tons/year or the equivalent of chicken feather meal of around 36.000 tons/year [1].According to BPS (2023) every year the number of chicken slaughter increases, in 2018 it was 3.137.707.479 heads and in 2019 it increased to 3.169.805.127 heads [2]. Until now, a small portion of chicken feathers are only used as upholstery filler, plant fertilizer, crafts or decorations, shuttlecocks and feather duster [3]. Most others are simply dumped in landfills, polluting the surrounding environment. Generally, producers of chicken feather waste deal with it by burning or burying the feathers, which will lead to new problems of soil and air pollution [4].

Chicken feathers are included in the waste that has the potential to be utilized because it has a very high protein content of around 80 - 90% [5]. According to Zerdani et al. (2004) chicken feathers contain about 1.2% fat, about 86% dry content and about 1.3% ash content [6]. Chicken feathers contain keratinized bonds that are difficult to dissolve in water, so the natural form of unprocessed chicken feather meal has low nutritional value. Therefore, if chicken feathers are to be used as feed raw materials, it is necessary to process them first. According to Puastuti (2007), the methods of processing chicken feathers are divided into four types: physical using high temperature and pressure, enzymatic, microbiological with fermentation and chemical with acids, bases or carbonation. In principle, processing of chicken feathers aims to weaken or break the bonds in keratin through hydrolysis [7]. Of the several processing methods, chemical processing with acids or bases (NaOH, HCl) is a more efficient processing because the processing method is easy and also cheap [1]. Therefore, it is necessary to conduct a literature study (review) in order to provide a clear picture of chicken feathers and their practical utilization through chemical processing. It is hoped that the review article on chicken feather processing can be a suggestion and also input for stakeholders in managing livestock waste for fish feed ingredients.

2. METHODS

The method used is descriptive by conducting literature review studies in various research journals such as SAINTEKS journals, Tropical Aquaculture Science, Journal of Aquaculture Management and Technology and so on. The type of literature that will be reviewed is research journals related to the use of local ingredients in feed both as substitutes and as additional ingredients in feed for the growth and survival of fish. The subject of the test animals to be discussed is specific to various types of fish. The results of the search for related journals were grouped according to the topic and obtained journals as the main reference. Furthermore, it is analyzed and reviewed according to each subtopic.

3. RESULTS AND DISCUSSION

3.1 Chicken Feather Composition

Feathers are part of the skin, formed from a controlled growth process through the activity of biological cells from the body's outermost tissue or epidermis [8]. Part of the chicken feather consists of down and the other half is the feather core which is a feather sheath that has a hollow tube structure. Part of the feather contains proteins that are difficult to dissolve and have a very strong structure in the form of keratin. Keratin is a fibrous protein that contains a lot of sulfur and is usually found in nails, hair, and feathers and other results from the hardening of epidermal tissue [9].

Chicken feathers are included in the waste that has the potential to be utilized because it has a very high protein content of around 80-90% [5]. According to Zerdani et al. (2004) chicken feathers contain about 1.2% fat, about 86% dry

content and about 1.3% ash content [6]. The nutrient content contained in chicken feather meal is in Table 1.

In Table 1, it can be seen that the dry matter content of chicken feathers is quite high (91.96-93.3%), making it a potential solid waste that can be utilized for fish feed ingredients. Moreover, it has a fairly high protein content (83.74-85.80%). However, the type of chicken feather protein is dominated by structural protein called keratin. According to Saravanan & Dhurai (2012) the protein content of chicken feathers consists of 91% keratin protein, 1% lipid and 8% water [12]. Keratin in chicken feathers is mostly composed of the amino acids cysteine, glutamine, proline, serine glycine, alanine, serine, cysteine and valine, as well as small amounts of lysine, methionine and tryptophan [13]. According to Kim & Patterson (2000) chicken feathers contain the minerals calcium 0.19%, phosphorus 0.04%, potassium 0.15%, and sodium 0.15% [14]. The amino acid composition in feather meal is similar to the amino acid composition in fish meal. Broiler feather meal has a variety of amino acids such as, 5.28% lysine, 2.91% arginine, 4.28% glycine, 2.04% histidine, 4.70% isoleucine, 2.11% methionine, 6.67% phenylalanine and 6.44% valine [15]. Meanwhile, according to Prado et al. (2016) the amino acids contained in fishmeal consist of: 8.83 mg lysine, 4.56 mg arginine, 5.82 mg glycine, 1.84 mg histidine, 4.21 mg isoleucine, 1.39 mg methionine, 4.79 mg phenylalanine and 5.24 mg valine [16]. This shows that feather meal has great potential to be developed as an alternative ingredient to fishmeal.

3.2 Chemical Improvement of Chicken Feather Quality

The natural form of unprocessed chicken feather meal has low nutritional value. Therefore, if chicken feathers are to be used as feed raw materials, it is necessary to process them first. According to Puastuti (2007), chicken feather processing methods are divided into four types, namely physical using high temperature and pressure, enzymatic, microbiological with fermentation and chemical with acids, bases or carbonation [7]. In principle, processing of chicken feathers aims to weaken or break the bonds in keratin through hydrolysis.

The four processing methods produce different digestibility and biological value of chicken feather hydrolysate. Microbiological processing produces good results but the processing is less effective because the necessary microbes are difficult to find and require expensive costs and for physical processing by heating will result in protein damage. Meanwhile, chemical processing is considered more effective and economical because it does not damage the protein in chicken feathers. Chemical processing also produces more natural chicken feather flour and can reduce damaged amino acids [17].

3.3 Mechanism of Chemical Processing

Chicken feathers contain keratin, which is classified as a fiber protein. Keratin can be broken down by chemical reactions, so that it can eventually be digested by trypsin and pepsin in the digestive tract. So if chicken feathers are to be used as feed ingredients, they must be processed first to increase their digestibility. Chicken feathers as feed ingredients are not simply dried and ground, but must be processed first, such as by adding chemical solutions. The mechanism of chemical processing of chicken feathers can be done by using HCl, NaOH or other chemical solutions. The following is an example of the processing mechanism of chicken feathers using 12% HCl [18]:

a) Chicken feathers are washed with running water until clean and dried.
b) The dried chicken feathers were mixed with 12% HCl in a ratio of 2:1 (w/v).
c) Stored for 4 days in a closed container.
d) After 4 days, chicken feathers were dried again.
e) Then the chicken feathers are ground and ready to be mixed with other fish feed ingredients.

Table 1. Nutritional content of chicken feather meal

No	Content	Chicken Feather Flour [10]	Chicken Feather Flour [11]
1.	Dry Material	93,3	91,96
2.	Crude Fiber	0,9	-
3.	Protein	85,8	83,74
4.	Fat	7,21	3,81
5.	Ash	3,5	2,76
6.	Ca	1,19	0,17
7.	P	0,68	0,13
8.	DE (kcal/kg)	3.000	3.952

Table 2. Chemical processing of chicken feathers

Processing	Treatment	Results	Reference
Chemical with HCl	The treatments consisted of 4 HCl concentrations (0, 6, 12 and 24%) and 3 hydrolysis times (2, 4, and 6 days).	The processing technique with 12% HCl and hydrolysis time of 4 days produced an optimal Hydrolysate of Chicken Feathers as a protein source in terms of the digestibility of Dry matter, Organic matter, solubility of Dry matter and fermentation products tested in vitro.	[18]
Physical Combination using autoclave and Chemical using 1 M HCl and 1M NaOH	The treatment consisted of four conditions including P0 (control), P1 [20% 1 M NaOH + autoclave (21 Psi)], P2 [20% 1 M HCl + autoclave (21 psi)] and P3 [10% 1 M NaOH + 10% 1 M HCl + autoclave (21 psi)].	The hydrolysis process using a combination of chemical [20% 1 M NaOH] and physical (autoclaving) processes (P1) was the best hydrolysis treatment.	[19]
Physical combination using autoclave at 2.5*105 Pa with temperature 121˚C for 30 minutes and Chemical using NaOH.	The first experiment consisted of the control treatment, 2, 12, 24 hours with 1.0 M NaOH. The second experiment consisted of the following treatments (1) Raw chicken feathers were autoclaved (2) Raw chicken feathers were soaked in 0.5% NaOH solution for 24 hours, then autoclaved.	Long-term treatment (24 and 12 hours) with NaOH increased feather solubility but resulted in lower protein retention, while NaOH addition followed by autoclaving resulted in higher protein content and increased in vitro pepsin digestibility.	[20]
Chemical with HCl and NaOH	The treatments carried out, namely: H-1: without hydrolysis, H-2: 1 M - NaOH 20%, H-3: 1 M - HCl 20%, H-4: 1 M - NaOH 10% + 1 M - HCl 10%	Chemical hydrolysis process using H-2 1M-NaOH 20% treatment is the best hydrolysis process compared to other treatments.	[15]
Chemical using H2SO4, HCl, HNO3 and H3PO4.	Treatment with 10% of each acid namely H2SO4, HCl, HNO3 and H3PO4.	Feathers hydrolyzed with HNO3 had the highest protein content (83.63%) compared to feather meal treated with other acids, followed by feather meal treated with HCL (82.40%).	[21]
Chemical with NaOH	Base hydrolysis with concentrations of 5%, 7.5% and 10% NaOH solution (1:6 ratio) and hydrolyzed for 4 hours at 80ºC using a hot plate and with the help of a magnetic stirrer at 1000 rpm.	Chicken feather hydrolysate with 5% NaOH solvent concentration showed optimum results with a yield of 70.24%, total protein 62.66%, total free amino acids 39.126% and protein molecular mass by SLS method showed the result of 4.31 kDa.	[22]

Table 3. Use of chicken feather meal as a raw material for fish feed

Processing	Organisms	Treatment in Feed	Results	Reference
Chemical with 12% HCl	Pomfret Fish *(Colossoma Macropomum)*	0,25,50,75 and 100% substitution with fishmeal.	The results showed that the addition of chicken feather meal up to 100% had no effect on survival rate, specific growth rate, feed conversion ratio, protein efficiency ratio, and protein retention but did have an effect on protein digestibility.	[1]
Chemical with HCl	Striped Catfish *(Pangasius hypopthalmus)*	Fish meal substitution with different doses of chicken feather silage, namely A (0%), B (25%), C (50%), D (75%) and E (100%).	Substitution of fishmeal with 25% doses of chicken feather silage is the best dose for protein digestibility and growth of catfish.	[24]
Chemical with HCl	Catfish *(Clarias gariepinus)*	Feeds were formulated to replace fish meal with feather meal at 0%, 25%, 50%, 75%, and 100% levels.	Replacement of fishmeal with feather meal improved growth and survival of Clarias gariepinus, especially at levels of 25% and 50% of feather meal.	[26]

According to Puspitasari et al. (2019) processing of chicken feather waste by adding HCl or NaOH solution serves to facilitate the crushing process and lyses the keratin compound which is the main constituent of chicken feathers [23]. Processing with 3% HCl acid and 12% HCl for 3 days produced dry matter digestibility of 20.3 and 45.5% [24]. The dry matter digestibility value of chicken feathers can be increased to 82.99% when using 24% HCl with a hydrolysis time of 6 days, but the chicken feather protein is damaged. The damage of chicken feathers is indicated by the change in color from white to brown due to the browning reaction and chemically indicated by the high levels of ammonia produced. According to the results of Puastuti (2007) research, it appears that chemicals and their concentrations as well as the length of processing time affect the dry matter digestibility of chicken feathers [7].

Increased hydrolysis due to chemical reactions can lead to decreased protein solubility. Protein hydrolysis is the process of breaking the peptide bonds of proteins into smaller components, such as peptides and amino acids. In addition, the hydrolysis process causes damage to the globular structure [15]. Based on SEM analysis conducted Said et al. (2019), there are differences in the structure of chicken feathers before and after chemical processing. The structure of unprocessed chicken feathers is still arranged in an orderly manner, while chicken feathers that have been processed have a significant change in structure such as elongated and irregular [15]. This shows that there is a process of protein denaturation caused by the hydrolysis process so that the structure of chicken feathers changes. This denaturation process occurs due to the reaction of amino acids in keratin with the chemical solution used. This chemical process is able to loosen polypeptide and disulfide bonds and dissolve the protective layer of wax found in feathers so that the feathers are brittle and easy to grind [25].

3.4 Use of Chicken Feathers in Fish Feed

Chicken feathers have benefits in aquaculture, one of which is for feed formulations in alternative feed substitutes. As in Table 3 is an application of the utilization of chicken feather meal in feed formulations in aquaculture.

Based on the results of the literature study in Table 3, there are only 3 recent publications of research on the use of chemically treated chicken feather meal in fish feed. The test fish used in the three studies were tilapia, catfish and catfish. The research was conducted by substituting fishmeal by chicken feather meal as much as 0%, 25%, 50%, 75% and 100% with maintenance media in the form of aquariums [1,26,27]. From the results of research that has been conducted, it is known that processed or partially hydrolyzed chicken feather meal at various levels in feed formulations can replace the role of fishmeal [28]. According to Nurhayati et al. (2017), feed utilization and growth rate of tilapia can increase with the addition of chicken feather meal and the best composition in the substitution of chicken feather meal in artificial feed is 25% [29]. Meanwhile, according to Suryaningrum (2011), chicken feather meal can be utilized as an alternative raw material to replace fishmeal by 25-30% in tilapia feed formulations [28].

4. CONCLUSION

Chicken feather meal contains high protein and amino acids that are good for fish. Chemical processing of chicken feathers is very effective and economical because it does not damage the protein in chicken feathers. In addition, it can produce more natural chicken feather meal and can reduce damaged amino acids. Chemicals, concentration and length of processing time affect the quality of chemically processed chicken feathers. Giving chicken feather meal with the right composition in feed can increase the growth and survival of several fish such as tilapia, catfish and catfish. Therefore, it can be concluded that chemically treated chicken feather meal has the potential to be used as an alternative raw material in making fish feed.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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