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Quality improvement of Tofu waste as the raw material of duck feed with fermentation of yeast culture

I Gusti Nyoman Gde Bidura *, Eny Puspani and I Made Suasta

Faculty of Animal Science, Udayana University, Denpasar-Bali, Indonesia.

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Abstract

The use of fermented products from probiotic microbes as supplement feed is expected to stimulate the growth and biocontrol of pathogenic bacteria in ducks with high feed efficiency. Feed biotechnology products based on tofu waste fermented with yeast culture (TWF) contain high levels of protein and the amino acid lysine, and contain probiotic microbes (10^7cfu/g). This research aims to examine the effect of fermenting tofu waste with yeast culture on the quality of tofu waste as a feed ingredient and the performance of ducks. The fermented product was tested on 240 male Bali ducks aged 2 weeks in a completely randomized design with four treatments and six replications. Each replication used 60 male Balinese ducks with homogeneous body weight. The four treatments were ducks given rations without TWF supplements as control (TWF0); diet supplemented with 2% TWF (TWF1); diet fed 4% TWF (TWF2); and rations given 6% TWF (TWF3). The results showed that supplementation of 4-6 TWF in feed significantly ($P<0.05$) increased body weight gain and feed efficiency.It can be concluded that the growth performance and feed efficiency of ducks increased significantly with the supplement of tofu waste fermented by yeast culture.

Keywords: Duck performance; Feed efficiency; Fermentation; Yeast culture

1. Introduction

Solid tofu waste is a by-product of tofu processing in solid form, and tofu waste production is quite high, ranging between 25-35% of total tofu production. The domestic tofu processing industry in Indonesia is very large, because tofu products have become globally popular as low-calorie vegetarian foods, so the tofu solid waste produced is very large, namely around 1,024 million tonnes/year [1]. In the tofu processing industry, the solid waste produced is around 40% of the total production capacity [2].

Fermentation is a simple way to increase the nutritional value of waste feed, such as tofu dregs [3]. As reported by [4,5] that the use of yeast *Saccharomyces* spp. or *Lactobacillus plantarum* in the fermentation process of feed waste (pineapple peel, rice bran, tofu waste), significantly increasing the protein and amino acid lysine content in fermented feed products. Fermented feed products still contain *Saccharomyces* spp. as much as 10^7cfu/g, and can act as a probiotic culture. Different results were reported by [6] that fermentation of tofu waste with *Rizophus oligosporus* significantly reduced the crude protein and crude fat content in tofu waste.

The use of tofu waste as poultry feed is very limited, because it has high crude fiber and has an impact on reducing poultry productivity [7,8,9]. Several researchers reported that the crude fiber and crude protein content of tofu waste had very large variations, namely 24.03% and 14.93% [6]; 19.80% and 16.22% [7]. Efforts to overcome the high crude fiber content and improve the protein quality of tofu waste, especially the amino acid lysine content, is through the fermentation process, which is a simple way to increase the nutritional value of feed and its palatability [10].

*Corresponding author: I Gusti Nyoman Gde Bidura

The content of amino acids, vitamins and digestibility of nutrients increases after fermentation [4]. According to [11], in the fermentation process biosynthesis of protein, essential amino acids and vitamins occurs, resulting in an increase in digestibility and quality of feeds. Feed products fermented by *Saccharomyces*spp. In the feed fermentation process it can act as a probiotic. *Saccharomyces* spp. it has been proven that it can act as a probiotic and can increase the absorption of food substances [12], and has been proven to be able to increase the digestibility of crude fiber and increase the nutritional value of feed.

Probiotics can change the digestive microbial ecosystem, and also produce natural antibiotics (bacitracin, hydrogen peroxide, acidolin), thereby affecting the health and performance of the host. Probiotics have a good influence on livestock, including improving health and feed use efficiency [13]. Giving probiotics through feed can actually increase the height of the villus and the depth of the jejunal crypts, so that the absorption of nutrient substances can be optimal.Besides that, probiotic microbes were able to suppress the population of pathogenics bacteria in the jejunum.

Increasing the rapid growth of ducks with high feed efficiency through the use of fermented feed products will increase business competitiveness to increase income. Based on this, researchers are interested in studying the effect of fermenting tofu waste with yeast culture on duck performance.

2. Material and methods

2.1. Experimental design, animals, housing and diets

Sample analysis was carried out at the Microbiology and Animal Products Technology Laboratory, Faculty of Animal Husbandry, Udayana University Denpasar. The feeding trial research was carried out at the Research Station, Faculty of Animal Husbandry, Udayana University, and Denpasar in an experimental room and has received approval from the Animal Care Ethics Commission from the Faculty of Veterinary Medicine, Udayana University, Denpasar. A total of 240 two-week-old healthy male Bali ducks were placed randomly in battery colony cages measuring: 2x1.5x0.5 m^3 (lengthxwidthxheight) made of bamboo and strong aluminum wire. Feeding twice a day, namely morning and evening. Drinking water was provided *ad libitum*. The 240 ducks were randomly divided into 4 food groups and six repetitions. Each replication used 60 two-week-old ducks with homogeneous body weight. Three feed treatment groups contained TWF (2%, 4%, and 6%), and one feed treatment group without TWF served as control feed. The basic feed used is commercial feed for growing ducks obtained from the local Poultry Shop.

2.2. The process of making tofu waste flour is fermented by Yeast culture

Before fermentation, fresh tofu waste (TW) are first squeezed with a double cloth and steamed for 30 minutes. After cooling, TW was then added to 5% sugar solution+0.5% mineral mixture+0.5 or 1.0% yeast culture (YC). After being mixed homogeneously, it was then placed in a plastic bag with small holes and incubated for three days at room temperature. After three days of incubation, the fermented tofu waste (TWF) was dried in the sun, then dried in an oven at 45^0C for two days. After drying, it was then finely ground into fine flour and ready to be analyzed in the laboratory and applied in feed trials on Bali ducks from 2-10 weeks of age.

2.3. Variable Measurement

Tofu waste and TWF samples were analyzed to determine dry matter (DM), organic matter, crude protein, crude fat, crude fiber, and ash determination was carried out in accordance with [14]. All tests were performed in triplicate. Final body weight (FBW), body weight gain (LWG), feed consumption (FI) and feed concentration ratio (FCR) were measured every week. Feed conversion ratio is a comparison between FI and LWG in the same time unit. The lower the FCR value, the higher the feed efficiency.

2.4. Statistical Analysis

The data obtained was analyzed using one-way ANOVA and if there was a significant difference ($P<0.05$) between treatments, it was continued with Duncan's multiple range test.

3. Results

3.1. Changes in nutrient tofu waste due to fermentation

Fermentation of tofu waste (TW) with tape yeast culture (*Saccharomyces* spp.) on dry matter content, metabolizable energy, crude protein, crude fat, crude fiber, minerals Ca and P, amino acids lysine and methionine, and number of yeast

Saccharomyces spp. presented in Table 1). The dry matter content of tofu waste fermented with 0.5% and 1% yeast tape, decreased respectively 0.92% and 1.01% lower compared to tofu waste without fermentation.

The results of laboratory analysis show that the gross energy content of tofu waste is 3407 kcal/kg (Table 1). The gross energy content of tofu waste fermented with 0.5% (TWF1) and 1% yeast tape (TWF2) increased, namely 1.58% and 2.61% higher than tofu waste without fermentation (TWF0). The metabolizable energy content of tofu waste is 2291kcal/kg, while the metabolizable energy content of TWF1 and TWF2 is 3.67% and 3.93% higher than TWF0. The crude fat content in TWF1 and TWF2 decreased, namely 6.181% and 11.49% compared to TWF0. The crude protein content in tofu waste that underwent fermentation with tape yeast (TWF1 and TWF2) increased, namely 6.63% and 7.75% higher than the protein content of TWF0.

Table 1 Nutrient content in tofu waste and fermented tofu waste (TWF) with *Saccharomyces* spp*.*

Nutrient	**Yeast culture level in the TW fermentation process (%).**		
	0	**0.5**	**1.0**
Dry matter, %	89.75	88.92	88.84
Gross energy, kcal/kg	3407	3461	3496
Metabolizable energy, kcal/kg	2291	2375	2381
Crude fat, %	2.35	2.19	2.08
Crude fibre, %	18.04	18.73	18.92
Crude protein, %	18.71	19.95	20.16
Lysine, %	0.91	1.79	1.88
Methionine, %	0.41	0.58	0.61
Calcium, %	0.31	0.29	0.30
Phosporus, %	0.19	0.27	0.28
Saccharomyces spp., colony forming units/g	none	$1.35x10^7$	$8.96x10^7$

There was a significant increase in the amino acid lysine content in TWF1 and TWF2, namely 27.16% and 58.02% higher compared to TW (unfermented tofu waste). Likewise, the amino acid methionine content increased in TWF1 and TWF2, namely 41.46% and 48.78% higher compared to TW. The fermentation process with tape yeast did not have a significant effect on the Ca and P mineral content.

3.2. Growth performance

Table 2 presents data on the performance of male Bali ducks aged 2-10 weeks that were fed feed containing tofu waste fermented by tape yeast (TWF). Providing 4-6% TWF in the feed significantly ($P<0.05$) increased the ducks' body weight, namely 15.77% and 15.55% higher than the control (TWF0). Meanwhile, giving 2% TWF in the feed had a non-significant ($P>0.05$) higher effect than the control. The group of ducks that received feed containing 2% and 4% TWF, their body weight gain during the 8 weeks of observation, was 20.93% and 20.65% significantly ($P<0.05$) higher than the control (without TWF0). Meanwhile, by giving 2% TWF in the feed, the weight gain was not significantly different ($P>0.05$) compared to the control.

TWF supplementation in feed had a significant effect ($P<0.05$) on feed consumption (Table 2). Feed conversion ratio is the comparison between feed consumption and body weight gain in the same unit of time. The FCR value is an indicator for assessing the level of feed efficiency. The lower the FCR value, the higher the feed efficiency. Likewise, the higher the FCR value, the lower the feed efficiency. TWF supplementation at levels of 4% and 6% in feed significantly ($P<0.05$) increased feed efficiency, namely 6.72% and 7.46% higher than the control. Supplementation of 2% TWF in feed did not have a significant effect ($P>0.05$) on feed efficiency.

Table 2 Performance of male Bali ducks fed with TWF supplementation from 2-10 weeks of age

Variables	TWF levels in feed (%)				SEM
	0	2	4	6	
Initial body weight, g/head	375.12[a]	374.85[a]	376.05[a]	375.92[a]	3.90
Final body weight, g/head	1502.36[a]	1540.19[a]	1739.26[b]	1735.93[b]	30.71
Body weight gains, g/head/56 days	1127.24[a]	1165.34[a]	1363.21[b]	1360.01[b]	29.92
Feed consumption, g/head/56 days	4531.50[a]	4649.71[a]	5112.04[b]	5059.24[b]	70.13
Feed consumption, g/head/days	80.92[a]	83.03[a]	91.29[b]	90.34[b]	2.07
Feed Conversion Ratio (FCR)	4.02[a]	3.99[a]	3.75[b]	3.72[b]	0.06

Note: Values with different letters on the same row are significantly different (P<0.05); SEM= standard error of the treatment means

4. Discussion

The nutrient content of tofu waste (TW) and fermented tofu waste with 0.5% tape yeast culture (*Saccharomyces* spp.) and 1% tape yeast culture is presented in Table 1. Tofu waste has quite high water and fiber content, so its utilization has not been optimal and its shelf life is relatively short. However, tofu waste can be used as a source of protein. The results of this research show that the crude protein content in TW is 18.04%, after fermentation with 0.5% and 1% tape yeast, the crude protein content of tofu waste increased to 19.95% and 20.16%. The crude protein content of tofu waste is much lower than that reported by [15] that the crude protein content of tofu waste is 27.55% and the other nutrient content is fat 4.93%, crude fiber 7.11%, and extract material without nitrogen 44.50%.

The amino acid lysine content in tofu waste increased 106.59% higher when fermented with 1% tape yeast culture. The research results of [5] reported that the amino acid composition of tofu waste fermented by *Lactobacillus plantarum* was valine 1.61%; methionine 0.69%; isoleucine 1.70%; leucine 2.12%; tyrosine 0.82%; phenylalanine 1.47%; 0.83% histidine; 1.63% lysine; 1.89% arginine; 0.61% tryptophan; and 0.55% cystine.

The energy content of tofu waste fermented using 0.5% and 1% yeast tape increased quite significantly. The increase in metabolized energy is due to the fermentation process with *Saccharomyces* spp. Research by [3] reported that fermented tofu waste contains 2830kcal/kg metabolizable energy; 21.66% CP; 2.73% EE and 17.06% CF. Yeast *Saccharomyces* sp. has two types of extracellular enzyme working systems, namely producing hydrolase enzymes which work to break down cellulose and hemicellulose and extracellular lignase secretion by depolymerizing lignin [13]. Feed products fermented by *Saccharomyces* spp. in the fermentation process, it can act as a probiotic. *Saccharomyces* spp. it has been proven that it can act as a probiotic and can increase the absorption of food substances [12], and has been proven to be able to increase the digestibility of crude fiber and increase the nutritional value of feed [16].

The research results showed that TW fermentation did not have a significant effect on the crude fiber content of tofu waste, but there was a slight increase compared to without fermentation. This increase was caused by increased mecelium from the yeast *Saccharomyces* spp. These results contradict the research of [7] who reported that the crude fiber content of tofu waste decreased by 13.08% when fermented with *Trichoderma viride* and showed no difference when fermented with *Saccharomyces cerevise.* Reported by [7] that the nutritional content of tofu waste without fermentation and fermentation, namely dry matter is 94.83% vs 93.75%; ash 2.57% vs 3.04%; crude fiber 17.35% vs 17.75%; crude fat 6.99% vs 2.45%; and crude protein 16.22% vs 23.28%. Sari et al.[8], the nutritional content of tofu waste fermented with *Saccharomyces cerevisiae* is metabolic energy 2830 kcal/kg; Ca 1.09%; and P 0.80%.

Fermentation is an easy way to increase nutritional value, and the results are palatable [10]. Ingredients that have undergone fermentation can increase amino acids and vitamins and increase nutritional digestibility. According to [11], during the fermentation process, the biosynthesis of vitamins, essential amino acids and protein occurs which can increase the nutritional content, resulting in an increase in the quality and digestibility of protein. Apart from that, according to [17], the enzyme activity produced by micro-organisms during the fermentation process causes chemical changes in the organic substrate.

Supplementation of 4-6% TWF in duck feed during the observation period (aged 2-10) can improve duck production performance (final body weight, weight gain, feed consumption and feed efficiency). This increase was made by TWF

containing the probiotic *S.cerevisiae* as much as $8.96x10^7$CFU/g (Table 1). Probiotic *Saccharomyces* spp. used in the tofu waste fermentation process can act as a probiotic in the digestive tract of ducks, so that it can increase enzymatic activity and absorption of food substances [13] which has an impact on improving duck performance. The use of probiotics in rations can increase the digestibility of dry matter and organic matter of rations, as well as improve the nutritional quality of feed.

The high content of the amino acid lysine in TWF can increase the process of protein absorption and synthesis in the body which has an impact on increasing the weight of ducks. As reported by [18,19] that the amino acid lysine is involved in physiological processes, especially in the body's protein synthesis, and helps digestion and utilization of nutrients [20]. Low-protein feed is generally cheaper than high-protein feed, so feed containing high lysine in low-protein feed can benefit the feed industry by saving protein material, and lysine supplementation can reduce nitrogen excretion, thereby reducing ammonia pollution in cages [21,22]. This was proven in research by [23], that the addition of the amino acid lysine in low-protein feed can increase the digestibility of certain amino acids and reduce nitrogen emissions in the cage. Increasing feed efficiency can influence protein synthesis and calcium intake which can influence the high and low levels of protein mass and calcium mass in products [24]. A similar thing was reported by [25] that the use of wet fermented feed products with probiotic microbes can improve poultry performance.

5. Conclusion

It can be concluded that fermenting tofu waste with yeast culture can increase the nutritional value of tofu waste and implementation in feed at a level of 4-6% can improve the performance of male Bali ducks aged 2-10 weeks.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest.

Statement of ethical approval

All ducks and procedures in this research have been approved by the Animal Ethics Commission from the Faculty of Veterinary Medicine, Udayana University, Denpasar.

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