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Effect of Distiller's Dried Grain with Soluble (DDGS) in Artificial Feed on the Growth, Protein Retention, and Survival Rate of the Pacific White Shrimp (*Litopenaeus vannamei*)

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ABSTRACT

The Pacific white shrimp (*Litopenaeus vannamei*) is in high demand within the community. Feed is a crucial component of the shrimp production process, accounting for 60-70% of the total production cost. The rising demand and high prices of raw materials for shrimp feed necessitate affordable alternative materials that are available in large quantities and have good nutritional profiles. Distiller's dried grain with solubles (DDGS) is a by-product rich in nutrients, containing 32% protein, 10% fat, and 11% crude fiber, making it a suitable alternative raw material for the Pacific white shrimp feed. This study aimed to evaluate the effect of DDGS in artificial feed on the growth of *L. vannamei* and to identify the optimal dosage of DDGS for this purpose. Four treatments were conducted: 0, 5, 10, and 15% DDGS per kilogram of feed. The test subjects were the Pacific white shrimp with an average weight of 1.06 ± 0.005 grams. The shrimp were reared in floating nets (3x2x1 m^3) placed in a tub (25x10 m^2) with a water depth of 9cm, at a stocking density of 720 shrimp per net for 80 days. The results indicated that the inclusion of DDGS significantly affected (P<0.05) total feed consumption (TFC), feed conversion ratio (FCR), feed utilization efficiency (EFU), absolute length growth (LG), absolute weight growth (WG), specific growth rate (SGR), protein retention (PR), and survival rate (SR). The optimum dosage of DDGS was found to be between 13.62 and 19.46% of the feed weight, which produced a TFC of 13.850 g, FCR of 1.48, EFU of 68.27%, absolute length of 8.388cm, SGR of 3.408% per day, PR of 72.15%, and SR of 87.095%. The optimum dosage for absolute weight gain was determined to be 3.78%, resulting in an absolute weight of 12.215g.

INTRODUCTION

The Pacific white shrimp (*Litopenaeus vannamei*) is a commodity in great demand in the community. Pacific white shrimp (*L. vannamei*) has many advantages for shrimp farming activities in ponds, including relatively fast growth, utilizing space more efficiently, and being more tolerant to environmental changes **(Purnamasari *et al.*, 2017)**. It is currently a leading commodity in aquaculture, which can be seen from the increase in its production. According to **KKP (2020)**, the Pacific white shrimp production in the 2019 period reached 517,397 tons and is targeted to increase by 250% in 2024 to 1,290,000 tons with a production value of 36.22 trillion in 2019 to 90.30 trillion in 2024. The increase in this production is an effort to fulfill the increasing demand in the market, especially in the export sector. According to **Darwantin *et al.* (2016)**, Indonesia exported 125,598 tons of the Pacific white shrimp in 2007. This number is quite large, reaching approximately 10% of the total production in Indonesia.

Feed is essential in the ongoing cultivation process and absorbs the highest costs. Almost half of the operational costs of the Pacific white shrimp cultivation process is needed to meet the needs or purchase of shrimp feed. This is reinforced by **Ulumiah *et al*. (2020)**, who stated that feed is an important factor in the Pacific white shrimp cultivation because feed absorbs 60-70% of the total operational costs of aquaculture activities. The primary raw material fish meal causes the high price of the commercial Pacific white shrimp feed. The high use of fish meal results in high market demand, and the price of raw materials is also high. The Pacific white shrimp feed generally contains fish meal because of its nutritional content and good palatability **(Qiu *et al.*, 2017; Anwar *et al.*, 2024)**. According to **Sudrajat and Effendi (2002)**, the nutritional content of fish meals includes 5.32% water, 57.35% protein, 4.32% BETN, 6.88% fat, 1.45% crude fiber, and ash 24.69%.

Minimizing the use of fish meals in shrimp feed can be done by adding raw materials from high-vegetable protein sources that can support the nutritional needs of shrimp. Vegetable protein can be used as a substitute or companion for fish meal as a raw material for shrimp feed. The popular vegetable protein used in shrimp feed is soybean meal flour. However, the popularity of using soybean meal flour in shrimp feed has resulted in an increase in demand and high prices of soybean meal flour due to competition from the poultry and livestock industrial sectors, which also utilize soybean meal flour in their feed **(Fessenden *et al.*, 2020)**. According to **Wawoh *et al.* (2019)**, the price of the Pacific white shrimp feed has now reached almost Rp20,000/kg. This high feed price is influenced by the scarcity of the main ingredients, fish meal and soybean meal, due to high demand. To overcome this, innovations need to obtain raw materials for shrimp feed that are relatively cheap and with good nutritional content. Corn waste by-products of bioethanol production in America and Europe are abundant and underutilized. Waste flour for bioethanol production, or what is known as *distiller's dried grain with soluble* (DDGS), has good nutritional content. According to **Oliveira *et al.* (2020)**, the nutritional content in the DDGS is about 28-32% crude protein, 10% fat, and 11% fiber. The production of waste flour from bioethanol production is increasing, resulting in the price of corn waste being much cheaper than that of soybean meal flour **(Rhodes *et al.*, 2015)**.

The nutritional content and relatively low price have resulted in the distiller's dried grain with soluble being used as raw material for livestock, poultry, and several types of fish **(Indarto *et al.*, 2011)**. DDGS has been widely studied and has given positive results. According to **Suprayudi *et al.* (2013)**, DDGS can be given to tilapia as much as 20% of the feed. This utilization as fish feed has previously been investigated by **Sandor *et al.* (2021)**, who obtained the results that the Wels catfish fed with an additional flour from DDGS had a reasonable growth rate seen from the FCR value of 1.29-1.36g/ g, SGR of 1.43 – 1.5g/ day, PER of 1.78 – 1.94%, and 27.7 – 30.2%. There was no fish mortality during the study. **Diogenes *et al.* (2018)** reported that the turbot fish fed an additional 10% of their diet with DDGS experienced a significant increase in biomass. The growth rate was considered reasonable, as indicated by a protein efficiency ratio (PER) of 1.9%, a feed utilization efficiency (EFU) of 1.0%, and a mortality rate of 0%. **Chatvijitkul *et al.* (2016)** reported that the addition of DDGS to tilapia feed has effectively supported fish growth, as evidenced by results showing a feed conversion ratio (FCR) of 0.91 to 1.02, an average biomass increases of 1.118 to 1.157 grams, and a survival rate of 98 to 100%. Similarly, **Herawati *et al.* (2024)** found that adding 10-15% DDGS to the feed enhanced the specific growth rate, absolute length growth, and total hemocyte count in *L. vannamei* shrimp.

MATERIALS AND METHODS

The test subjects were the Pacific white shrimp, each weighing 1.06 ± 0.005 grams. The shrimp were healthy, actively swimming, and showed no injuries. They were reared in floating net cages (3 x 2 x 1m^3) at a density of 720 shrimp per net. The feed was supplemented with distiller's dried grain with soluble (DDGS) and was available in 2 and 3mm pellet sizes. Feeding occurred four times a day—at 7 AM, 11 AM, 3 PM, and 9 PM—according to a pre-designed feeding program. The maintenance medium used was seawater with a salinity of 30-34ppt, which is suitable for Pacific white shrimp, as recommended by **SNI (2014)**.

The research was conducted at the Marine Science Techno Park (MSTP) in Jepara. The experimental design was completely randomized (CRD) with four treatments and three replications. The treatments were as follows:

- **A:** 0% DDGS added to the feed formulation
- **B:** 5% DDGS added to the feed formulation
- **C:** 10% DDGS added to the feed formulation
- **D:** 15% DDGS added to the feed formulation

The additional doses of DDGS were based on the research conducted by **Novriadi *et al.* (2022)**. The feed used in this study consisted of artificial feed, with the formulation detailed in Table (1).

Table 1. Arrangement of feed formulations

Ingredient (%)	Treatment			
	A	B	C	D
Soybean meal	25.0	22.5	20.0	17.5
Poultry by product meal	20.3	20.3	20.3	20.3
Fish meal	8.0	8.0	8.0	8.0
DDGS	0.0	5.0	10.0	15.0
Tuna hydrolysate	2.0	2.0	2.0	2.0
Squid liver powder	6.0	6.0	6.0	6.0
Wheat flour	31.9	29.3	26.8	24.2
Soya lecithin	1.5	1.5	1.5	1.5
Fish oil	1.0	1.0	1.0	1.0
Monocalcium phosphate	1.8	1.8	1.8	1.8
L-lysine	0.00	0.04	0.09	0.14
DL-methionine	0.19	0.18	0.17	0.17
L-threonine	0.08	0.08	0.08	0.09
Mineral premix	1.20	1.20	1.20	1.20
Vitamin premix	0.41	0.41	0.41	0.41
Magnesium sulphate	0.35	0.35	0.35	0.35
Choline chloride	0.20	0.20	0.20	0.20
Antimold	0.12	0.12	0.12	0.12
Protein*	38.96	38.64	38.61	38.60
Fat*	6.96	6.71	7.02	7.14
NFE*	30.69	32.03	34.10	34.73
Moisture	11.24	10.96	8.00	6.48
Crude fiber	1.54	1.52	1.44	2.67
Ash	10.61	10.14	10.83	10.38

Note: *Saraswanti Indo Genetech Laboratory, Bogor, West Java, Indonesia (2022).

The data observed in this study included total feed consumption (TFC), feed conversion ratio (FCR), efficiency of feed utilization (EFU), absolute length growth (LG), absolute weight growth (WG), specific growth rate (SGR), protein retention (PR) and survival rate (SR) that were calculated based on the following formulas, as detailed in the study of **Zooneveld *et al*. (1991)**:

TFC (g) = 1^{st} day of feed (g) + 2^{nd} day of feed (g) + .. + n^{th} day of feed (g) … (1)

$$\text{F.C.R.} = \frac{\text{Feed intake (g)}}{\text{Body weight gain (g)}} \ldots (2)$$

$$\text{EFU (\%)} = \frac{\text{Final weight} - \text{initial weight}}{\text{Weight of diet consumed}} \times 100 \ldots (3)$$

L.G. (cm) = Final body length (cm) - Initial body length (cm) … (4)

W.G. (g) = Final body weight (g) - Initial body weight (g) … (5)

$$\text{S.G.R. (\% per day)} = \left(\frac{\text{(in weight of biomass at the final} - \text{in weight of biomass at the beginning)}}{\text{Time of experiment}}\right) \times 100 \ldots (6)$$

$$\text{P.R.} = \left(\frac{\text{Protein of final weight (g)} - \text{protein of initial weight (g)}}{\text{The total Protein consumed (g)}}\right) \times 100 \ldots (7)$$

$$\text{S.R.} = 100\% \times \left(\frac{\text{Final count}}{\text{Initial count}}\right) \ldots (8)$$

Water quality

The water quality parameters observed in this study include temperature, pH, salinity, dissolved oxygen (DO), and total ammonia (TAN). Water quality measurements for temperature, salinity, pH and dissolved oxygen were carried out 2 times a day, morning at 8 am and in the afternoon at 4 pm, while the total ammonia was tested at the beginning and end of the study.

RESULTS

Total feed consumption (TFC)

The study's results on the effect of adding DDGS to feed on the growth of white shrimp (*L. vannamei*) by total feed consumption are presented in Fig. (1).

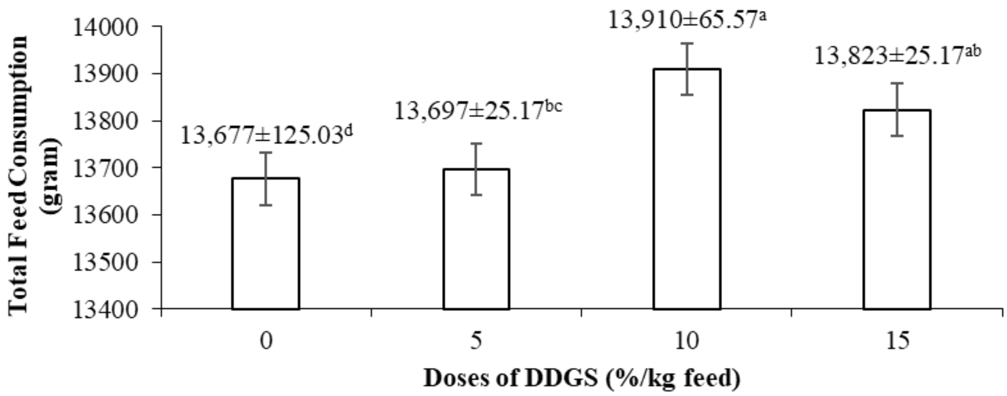

Fig. 1. Total feed consumption of white shrimp (*L. vannamei*)

Based on data in Fig. (1), the highest total feed consumption in treatment C was 13,910 grams, and the smallest in treatment A was 13,677 grams, with a difference of 233 grams.

Feed conversion ratio (FCR)

The results of the study on the effect of adding DDGS to feed on the growth of white shrimp (*L. vannamei*) by feed conversion ratio are presented in Fig. (2).

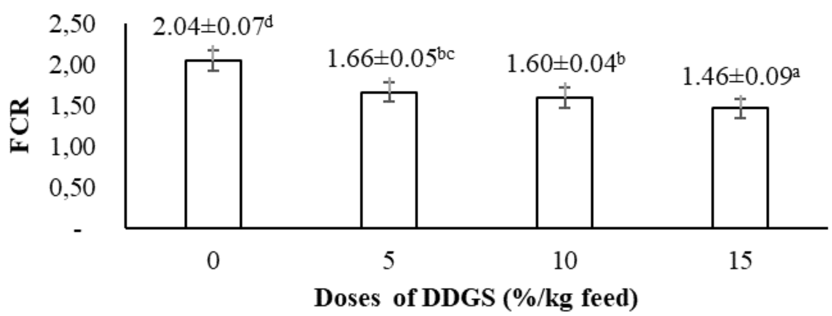

Fig. 2. Feed conversion ratio of white shrimp (*L. vannamei*)

Based on the figure above, the best feed conversion ratio was 1.46 (treatment D), while the worst in treatment A was 2.04, with a difference of 0.58.

Efficiency of feed utilization (EFU)

The results of the study on the effect of adding DDGS in feed on the growth of white shrimp (*L. vannamei*) by efficiency of feed utilization are presented in Fig. (3).

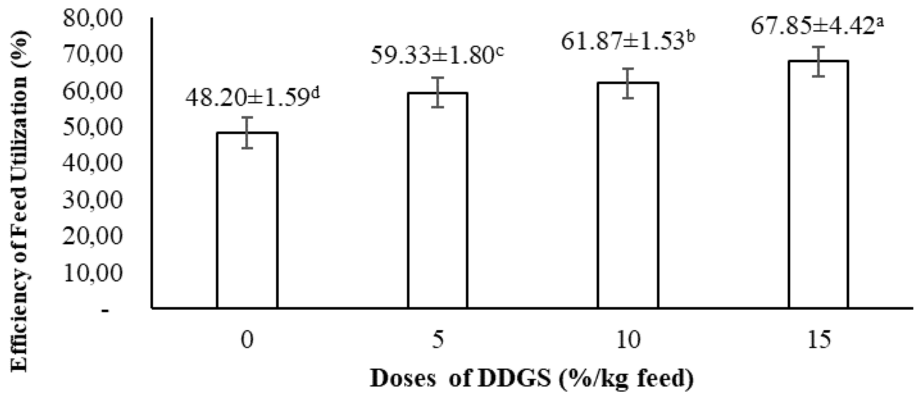

Fig. 3. Efficiency of feed utilization of the white shrimp (*L. vannamei*)

Based on information presented in Fig. (3), the highest efficiency of feed utilization value in treatment D was 67.85%, whereas the lowest in treatment A was 48.20%, with a difference of 19.65%.

Absolute length growth (LG)

The results of the study on the effect of adding DDGS to the feed on the growth of white shrimp (*L. vannamei*) by absolute length growth are presented in Fig. (4).

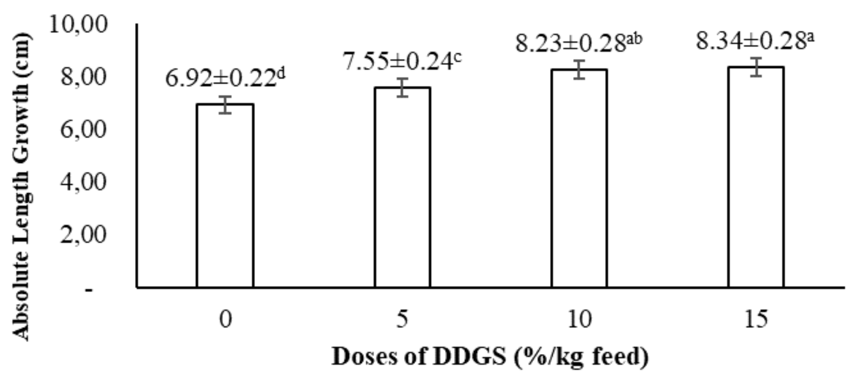

Fig. 4. Absolute length growth of white shrimp (*L. vannamei*)

Fig. (4) reveals that, the highest absolute length growth value was 8.34cm (treatment D), however the lowest was 6.92cm (treatment A), with a difference of 1.42cm.

Absolute weight growth (WG)

The results of the study on the effect of adding DDGS to the feed of the white shrimp (*L. vannamei*) on its growth through absolute weight growth are presented in Fig. (5).

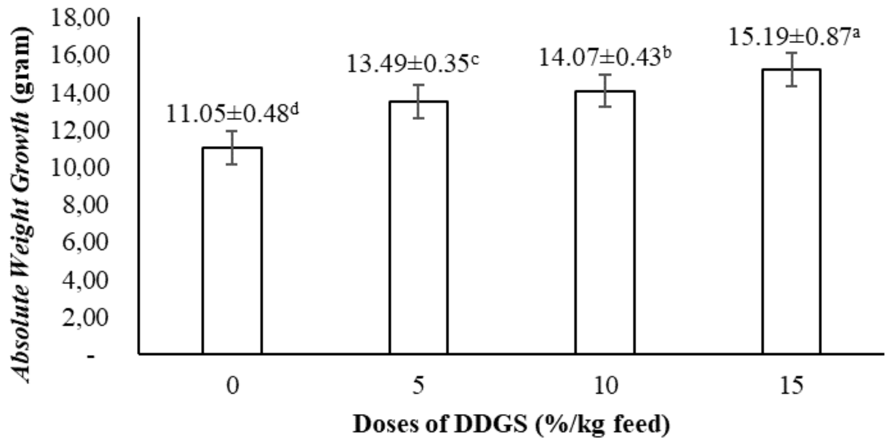

Fig. 5. Absolute weight growth of the white shrimp (*L. vannamei*)

Based on the figure above, the highest absolute weight growth value was 15.19 grams (treatment D), conversely the lowest was 11.05 grams (treatment A), with a difference of 4.14 grams.

Specific growth rate (SGR)

The results of the study on the effect of adding DDGS in feed on the growth of white shrimp (*L. vannamei*) by specific growth rate are presented in Fig. (6).

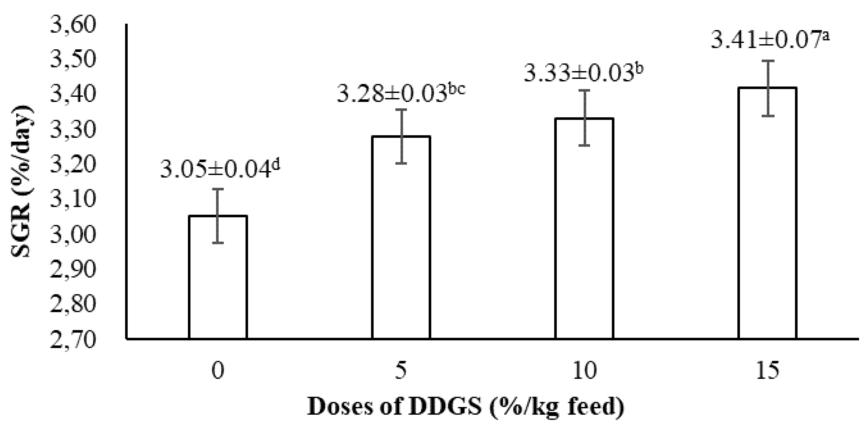

Fig. 6. The specific growth rate of the white shrimp (*L. vannamei)*

Based on the figure above, the highest specific growth rate in treatment D was 3.41%/day, on the other hand the smallest in treatment A was 3.05%/day, with a difference of 0.36%/day.

Protein retention (PR)

The results of the study on the effect of adding DDGS in feed on the growth of white shrimp (*L. vannamei*) by protein retention are presented in Fig. (7).

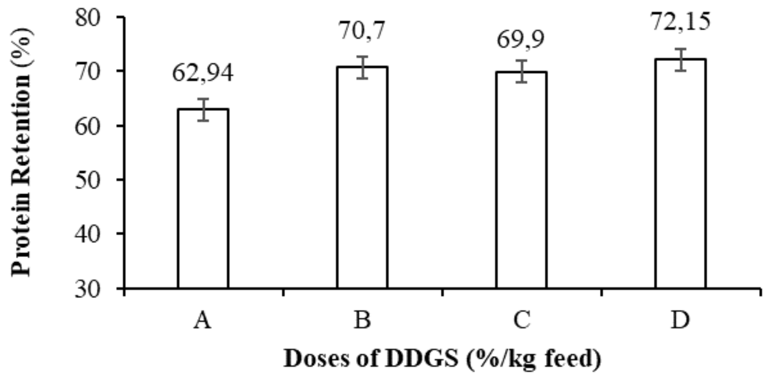

Fig. 7. Protein retention of the white shrimp (*L. vannamei*)

Based on the figure above, the highest protein retention value was 72.15% (D), while the lowest was 62.94% (A).

Survival rate (SR)

The results of the study on the effect of adding DDGS in feed on the growth of white shrimp (*L. vannamei*) by survival rate are presented in Fig. (8).

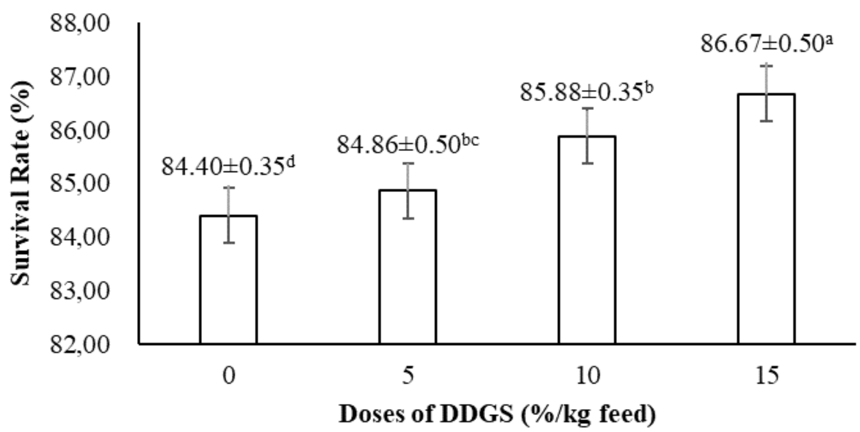

Fig. 8. Survival rate of the white shrimp (*L. vannamei*)

Based on the figure above, the highest survival rate in treatment D was 86.67%, and the lowest was 84.40% (A). The results of the analysis of variance of data on total feed consumption (TFC), feed conversion ratio (FCR), efficiency of feed utilization (EFU), absolute length growth, absolute weight growth, specific growth rate (SGR), protein retention (PR) and survival rate (SR) showed that the use of DDGS in artificial feed had a significant effect on the parameters' values (P<0.05).

Water quality

The results of measurements of several water quality parameters, including salinity, temperature, pH, DO, and total ammonia during the study are presented in Table (2).

Table 2. Results of water quality measurement in the Pacific white shrimp (*L. vannamei*) rearing media during the study

No	Variable	Unit	Result	
			Morning	Evening
1	Salinity	ppt	33-35	32-35
2	Temperature	^{0}C	28.00-29.80	28.00-33.50
3	pH	-	7.50-8.32	7.42-8.43
4	DO	mg/L	5.30-6.80	4.89-6.98
5	TAN	mg/L	0.000-0.706	

The water quality results show that the water quality during maintenance was optimal for cultivation activities and could support the growth of *L. vannamei* shrimp.

DISCUSSION

Growth performance

The results of the analysis of variance showed that the use of DDGS in the artificial feed had a significant effect (P<0.05) on the total consumption, feed conversion ratio, efficiency feed utilization, length growth, weight growth, specific growth rate, protein retention, and survival rate of the Pacific white shrimp. The highest total feed consumption value was in treatment C with 13.910±65.57%, the value of the feed conversion ratio from the lowest to the largest in a row, namely in treatment D, recording 1.46±009, the highest feed utilization efficiency value was in treatment D, with 67.85±4.42%, the highest absolute length growth value was in treatment D, assessing a value of 8.34±0.28cm, the highest absolute weight growth value was in treatment D with 15.19±0.87g, the highest specific growth rate value was in treatment D of 3.41±0.07%/day, the highest protein retention value in this study was in treatment D at 72.15%, and the *survival rate* in this study was in treatment D recording 86.67±0.50%.

Using different DDGS in the feed causes the total consumption produced to be different. Differences in the size and growth rate of the Pacific white shrimp caused the difference in total feed consumption between treatments. Large shrimp will consume more feed than small shrimp. This is reinforced by **Rolin *et al.* (2015)**, who postulated that the response of shrimp to feed can cause a difference in feed consumption between treatments. There are differences in shrimp's size and growth rate, thus more considerable shrimp need and consume more feed than smaller shrimp. The total consumption of different feeds can be influenced by palatability, nutritional content, temperature, age or stadia, weight, and stomach capacity.

Palatability is related to attractiveness, which will affect the response of shrimp in searching for feed, taking feed, and swallowing or accepting the feed given. High palatability in a feed will cause the feed to be favored by shrimp, hence the total feed consumption obtained will also be high. **Pamungkas (2013)** stated that the factors influencing feed consumption include nutrient content, palatability, temperature, age, body weight, and stomach capacity. This is also reinforced by **Afriyanti *et al*. (2020)**, who stated that the quality of feed, which includes palatability, deliciousness, and nutritional content, can affect high feed consumption levels. DDGS added to the feed resulted in the feed containing several amino acids, including glycine and alanine, which could affect the palatability and the amount of feed consumed. According to **Suprayudi *et al.* (2013)**, the palatability of feed is closely related to the attractiveness provided by free amino acids (glycine, alanine, and betaine), which will then affect the response in foraging, taking, and swallowing (acceptability).

The results showed that using DDGS in artificial feed with a dose of 15% got the lowest FCR value of 1.46. The FCR obtained from the study ranged from 1.46-2.04, which is higher than the study of **Gyan *et al.* (2021)**, which showed that shrimp with DDGS in their feed formulation obtained FCR in the range of 1.6-2.3. The value of a good feed conversion ratio (FCR) is seen from its small value. The feed conversion ratio's size will affect the resulting feed's utilization. The feed conversion ratio's value is related to the efficiency of feed utilization. The better the feed efficiency that shrimp can utilize, the better the feed conversion ratio value produced, while the worse the feed utilization will lead to a higher feed conversion ratio value. This is reinforced by **Sari *et al.* (2013)**, who stated that the lower feed conversion value has a better feed utilization efficiency level and vice versa; if the feed conversion is large, the feed utilization efficiency level is not good.

The conversion ratio value obtained during the research period can still be said to be suitable for mass-scale Pacific white shrimp culture in ponds. The best feed conversion ratio value obtained in the study was 1.46, which means that to produce 1kg of the Pacific white shrimp meat, 1.46kg of feed is needed. This is supported by **Ariadi *et al.* (2020)**, who reported that a feed conversion ratio (FCR) of 1.31 in shrimp farming indicates that 1.31kg of feed is required to produce 1kg of shrimp biomass. Similarly, **Witoko *et al.* (2018)** noted that the FCR for the Pacific white shrimp cultured in ponds typically ranges from 1.3 to 1.7.

The addition of DDGS ingredients in shrimp feed formulations can reduce the conversion value of the resulting feed because of its balanced nutritional and amino acid composition. This was confirmed by **Gyan *et al*. (2021)**, who stated that the white shrimp fed DDGS feed obtained an excellent feed conversion value since DDGS feed had a balanced composition of nutrients and amino acids (AA) in the shrimp feed given.

Feeds with a high feed utilization efficiency value show better feed content. Good feed content can be utilized efficiently and is helpful for shrimp activity and growth. This is reinforced by **Iskandar *et al.* (2015)**, who stated that whether the quality of a feed is good or not can be seen from the feed conversion value and feed efficiency value, where the more significant the feed efficiency value, the more efficient the fish in utilizing the feed consumed for growth. Based on the results obtained, DDGS can increase the efficiency of feed utilization, which shows that the use of DDGS in artificial feed formulations can increase the value of energy retention better than artificial feeds without DDGS. The nutritional content of DDGS ingredients added to the shrimp feed formulation contains both macro and micronutrients that can meet the nutritional needs of shrimp during the rearing process. According to **Guo *et al.* (2018)**, the composition of DDGS contains several nutritional sources, including protein, fat, phosphorus, and vitamins, which can improve growth performance and feed utilization and increase immunity. It is suspected that the added DDGS ingredients in the shrimp feed formulation can increase the digestibility of the feed and can affect the efficiency value of the resulting feed utilization. DDGS can increase the content of trypsin and amylase in the shrimp intestine, which plays a role in the shrimp digestion process, according to **Gyan *et al.* (2021)**, who stated that the inclusion of DDGS ingredients in the shrimp feed formulation increased the trypsin and amylase content in the shrimp intestines which played a role in increasing the digestibility of the feed.

Using 15% DDGS in the feed given to the Pacific white shrimp (*L. vannamei*) can affect the growth length of the Pacific white shrimp. The protein content in the feed and the presence of amino acids needed by the Pacific white shrimp affect the species' growth. Protein is the main component of nutrition needed for aquaculture growth and survival rate. According to **Suri *et al.* (2018)**, feed is one of the determinants of growth and survival rates. Biologically, the feed consumed by shrimp will be processed in the body, and then the nutritional elements in the feed will be absorbed and used to build tissue and meat in the shrimp's body. The content of DDGS, which consists of protein, fat, and energy, can affect the growth and immunity of Pacific white shrimp. This is confirmed by **Gyan *et al.* (2021)**, who stated that proteins, fats, energy, and lipids that can increase the growth and immunity of Pacific white shrimp during the cultivation process can be found in DDGS material. Growth of the Pacific white shrimp is characterized by molting or changing the skin, and it indicates that the growth of the Pacific white shrimp is going well. This is coincided with the findings of **Marzuqi and Bagus (2021)**, who stated that the intensity of the shrimp supports the increase in length in white shrimp after molting, where the shrimp's appetite will increase after the molting to satisfy its appetite.

Feeding with good nutritional content can support the growth rate of cultured shrimp. According to **Riyanti *et al*. (2020)**, adequate feed consumption and nutrient content in the feed can significantly affect the growth of the average weight and length of individual post-larvae white shrimp. This also follows the study of **Nuhman (2009)**, who clarified that the daily growth rate increases along with the increase in the percentage of feeding because the increase in feed means the more significant the energy consumed by the shrimp. This energy is not only used for activities but also for growth. The shrimp intestine is an essential organ in immunity, digestion, and absorption of nutrients in the Pacific white shrimp body. The addition of DDGS material to the given feed formulation showed morphological changes in the shrimp intestine, namely an increase in microvilli and intestinal wall thickening, which played a role in the process of absorption of nutrients from the given feed and then utilized further for shrimp growth, one of which was the final biomass of shrimp. This is confirmed by **Gyan *et al.* (2021)**, who observed that DDGS included in shrimp feed showed changes in the intestinal morphology and increased digestive enzymes in the intestine, where the intestine plays a vital role in protecting shrimp from disease, digestion, and absorption of nutrients.

The value of the specific growth rate of the Pacific white shrimp fed DDGS in artificial feed was higher than that of the Pacific white shrimp fed artificial feed without DDGS. The protein and fat content can influence the growth rate in the feed given. Appropriate protein can promote growth by building new muscles, cells, and tissues and being an energy source. The high growth rate is also proportional to the high efficiency of feed utilization. According to **Isnawati *et al*. (2015)**, the high growth rate is influenced by the increase in protein and body fat content, which functions as a builder of muscles, cells, and tissues as well as a source of energy. A high growth rate associated with high feed efficiency indicates that feed efficiently meets energy needs, and the rest is for growth.

DDGS contains complex nutrients, including protein, fat, crude fiber, energy, and amino acids, that can support the ongoing growth process. In the ongoing growth process, lysine and methionine limit amino acids in shrimp feed, where a deficiency can inhibit growth. In the DDGS material, it was found that the amino acid content in the form of lysine and methionine was optimal for shrimp growth. This is confirmed by **Diogenes *et al.* (2019)**, who stated that DDGS proved to be a good source of methionine, which was utilized in the growth process of the Pacific white shrimp during the rearing process.

The retention of protein in treatment D was higher, which indicated that the *L. vannamei* shrimps were more able to convert the protein in the feed into protein stored in their bodies when compared to fish in other treatments. According to **Setiawati *et al.* (2013)**, protein retention is several proteins originating from the feed given and then converted into protein stored in the bodies of fish and shrimp. The high or low protein retention values indicate the protein quality in the feed that the shrimp body can utilize. **Dewi and Evi (2017)** stated that the protein retention value indicates the protein deposition index, which is utilized to form body tissues for growth. Protein will generally be digested into amino acids, which will then be used for cell repair, metabolic energy sources, and biological functions, and the rest is stored in the body. The amino acid content in DDGS shows a high protein retention value. In a previous study, **Halver (2002)** argued that a deficiency of one or more essential amino acids will limit other essential amino acids in protein synthesis. According to **Suprayudi *et al*. (2013)**, arginine and lysine are essential amino acids in the body that function as the immune system, energy storage, and antioxidants.

The survival value during the study showed promising results, whereas the results from all treatments showed that the survival value was above 84%. This is presumably due to some of the content in DDGS, such as nucleotides, yeast, and beta-glucan, as well as the antioxidant properties of DDGS that can increase immunity in shrimp to increase the survival value until the end of the study. This is reinforced by **Gyan *et al.* (2021)**, who stated that the nucleotides, yeast, and beta-glucans found in DDGS have a role in increasing the immune system and disease resistance in shrimp. Antioxidant properties that increase resistance to disease by counteracting free radicals. Optimal environmental conditions and adequate feed influence an excellent survival rate. The conditions of the rearing environment in this study were within a reasonable range that allowed the shrimp to grow well. According to **Anugraha *et al.* (2014)**, factors that can affect the level of survival are internal and external. Internal factors come from the shrimp itself. Shrimps experience stress due to careless treatment, so the mortality is high. External factors that influence include environmental conditions. According to **SNI (2014)**, the survival value of the Pacific white shrimp with a reasonable 70-80-day rearing period is above 83%.

Water quality

The supporting parameters of this research are water quality parameters. The water quality measurement parameters are salinity, temperature, pH, DO, and TAN. Water as a living medium for shrimps in captivity must meet the requirements for both quality and quantity. This measurement aims to determine the risk in matters relating to production activities that cause fish deaths. According to **Erfanto *et al.* (2013)**, water quality management aims to reduce the risk of production failure by monitoring water quality parameters during the cultivation process. The leftover feed will decompose and can cause water quality to become poor and toxic. According to **Marzuqi *et al.* (2012)**, feeding in excessive amounts causes problems such as causing a decrease in water quality due to pollution.

The water quality measured in this study included salinity, temperature, pH, DO, and TAN, which had a range of values during the study; salinity in the morning ranged from 33-35ppt, and in the afternoon, around 32-35ppt. **Adipu (2019)** in this respect noted that the salinity for rearing the Pacific white shrimp in ponds is 30-35ppt. Temperature values during the study in the morning ranged from 28.00-29.80°C, and for the afternoon ranged from 28.00-33.50°C. According to **SNI (2014)**, the optimal temperature for the Pacific white shrimp cultivation is 28-33°C. The pH value during the morning research was 7.50-8.32 and around 7.42-8.43 for the afternoon. In this context, **SNI (2014)** demonstrated that the optimal pH level for the Pacific white shrimp ranges from 7.5-8.5.

Dissolved oxygen (DO) during the study in the morning ranged from 5.30-6.80mg/ L, and in the afternoon ranged from 4.89-6.98mg/ L. **SNI (2014)** stated that dissolved oxygen levels during pacific white shrimp culture are optimal at >4mg/ L. The total ammonia (TAN) value during the study was 0.000-0.706mg/ L. According to **Rusdy *et al.* (2021)**, the TAN content in the waters during the Pacific white shrimp cultivation process is still within the safe tolerance limit, which is a maximum of 1ppm.

CONCLUSION

The addition of DDGS in the artificial Pacific white shrimp feed formulation significantly affected (P<0.05) TFC, FCR, EFU, absolute length, weight, SGR, PR, and survival rate. The optimum dose of the addition of DDGS is in the range of 13.62-19.46%/ weight of feed capable of producing TFC (13.850 grams), FCR (1.48), EFU (68.27%), absolute length (8.388cm), absolute weight (15.144 grams), SGR (3.408%/day), RP (72.15%) and SR (87.095%).

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REFERENCES

Afriyanti, E. A.; Hasan, O. D. S. and Djunaidah, I.S. (2020). Growth Performance of Gourami Fish Osphronemus gouramy Lacepade, 1801 Fed with a Combination of Fish Meal and Azolla Meal (*Azolla microphylla*). Jurnal Ikhtiologi Indonesia. 20(2):133-141.

Anggraeni, N. and Hatmiyarni, T. H. (2022). Consumer acceptance and nutritional value of catfish cendol (*Clarias batrachus*) with the addition of coffee powder. Agromix, 13(1), 1-8. https://doi.org/10.35891/agx.v13i1.2655

Anugraha, R. S.; Subandiyono and Arini, E. (2014). The Effect of Using Pineapple Fruit Extract on Protein Utilization Level and Growth of Goldfish (*Cyprinus carpio*). Journal of Aquaculture Management and Technology. 3(4): 238-246.

Anwar, A.; Zainuddin; Djawad, M. I.; Aslamyah, S.; Saade, E.; Karim, M. Y.; Trijuno, D. D.; Murni; Syafiuddin; Mohammed, A. A. and Taukhid, I. (2024). Effect of Soybean Meal Substitution Using Raintree (*Samanea saman*) Seed Meal on the Physical Quality of Feed and Growth Performance of the Juvenile White Shrimp, *Litopenaeus vannamei*. Egyptian Journal of Aquatic Biology & Fisheries, 28(4): 2249 – 2274

Ariadi, H.; Wafi, A. and Supriatna. (2020). Relationship between Water Quality and FCR Value in Intensive Vaname Shrimp Cultivation (*Litopenaeus vannamei*). Jurnal ilmu Perikanan. 11(1) : 44 – 50.

Bhavan, P. S.; Ruby, S. A.; Poongodi, R.; Seenivasan, C. and Radhakrishnan, S. (2010). Efficacy of Cereals and Pulses as Feeds for the Post-larvae of the Freshwater Prawn (*Macrobrachium rosenbergii*). Journal of Ecobiotechnology 2:5 (09-19).

Chatvijitkul, S.; Davis, D. A. and Lim, C. E. (2016). Lipid Extracted Distillers Dried Grains With Solubles (LE-DDGS) as a Partial Replacement for Soybean Meal in Hybrid Tilapia (*Oreochromis niloticus* × *O. aureus*) Diets. Aquaculture. 459:131-136.

Darwantin, K.; Sidik, R. and Mahasri, G. (2016). Efficiency of Immunostimulant Use in Feed on Growth Rate, Immune Response and Survival of Vannamei Shrimp (*Litopenaeus vannamei*). Jurnal Biosains, 18(2):1-18.

Dewi, R. R. S. P. S. and Tahapari, E. (2017). Utilization of Commercial Probiotics in Catfish (*Clarias gariepinus*) Farming. Jurnal Riset Akuakultur. 12(3):275-281.

Diogenes, A.F.; Castro, C.; Miranda, A.C.; Teles, A.O. and Peres, H. (2018). Dietary Replacement of Fishmeal by Corn Distillers Dried Grains with Solubles (DDGS) in Diets for Turbot (*Scophtalmus maximus*, Linneaus, 1758). Aquaculture., 492:113-122.

Effendie, M. I. (1997). Metode Biologi Perikanan. Cetakan Pertama. Yayasan Bogor: Pustaka Nusatama. 160 hlm.

Fessenden, S.W.; Ross, D.A.; Block, E. and Van Amburgh, **M.E**. (2020). Comparison of milk production, intake, and total-tract nutrient digestion in lactating dairy cattle fed diets containing either wheat middlings and urea, commercial fermentation by-product, or rumen-protected soybean meal. Journal of dairy Science., 103(6):5090-5101. https://doi.org/10.3168/jds.2019-17744.

Guo, J.; Ries, J.; Salze, G.; Rhodes, M.; Tilton, S. and Davis, D.A. (2018). Using high protein distiller's dried grain product to replace corn protein concentrate and fishmeal in practical diets for the Pacific white shrimp *Litopenaeus vannamei*. Journal World Aquaculture Society. 1-10. https://doi.org/10.1111/jwas.12606.

Gyan, W.R.; Yang, Q.H.; Tan, B.; Dong, X.; Chi, S.; Liu, H. and Zhang, S. (2021). Effects of replacing fishmeal with dietary dried distillers grains with solubles on growth, serum biochemical indices, antioxidative functions, and disease resistance for *Litopenaeus vannamei* juveniles. Aquaculture Reports. https://doi.org/10.1016/j.aqrep.2021.100821

Halver, J. E. (2002). Fish nutrition. Third Edition. Academy Press Inc, New York. 798 p.

Herawati, V. E.; Yosaldika A.; Prayitno, S. B.; Novriadi, R. and Windarto, S. (2024). Effect of bioethanol waste flour on feed for the growth and blood profile of vannamei shrimp (*Penaeus vannamei*). AACL Bioflux, 17(5):1997-2004

Indarto, E.; Jamhari; Zahra, F.; Zuprizal and Kustantinah. (2011). The Effect of Using Dried Distillers Grain With Soluble (DDGS) in Low Energy Rations on Carcass, Abdominal Fat, and Liver of Broiler Chickens. Buletin Peternakan. 35(2): 71-78.

Iskandar, R. and Erlifadah. (2015). Growth and Feed Efficiency of Nile Tilapia (Oreochromis Niloticus) Fed with Kiambang-Based Artificial Feed. Ziraa'ah. 40(1): 18-24.

Isnawati, N.; Sidik, R. and Mahasri, G. (2015). Potential of Papaya Leaf Powder to Increase Feed Utilization Efficiency, Protein Efficiency Ratio and Relative Growth Rate in Tilapia (*Oreochromis niloticus*) Cultivation. Jurnal Ilmiah Perikanan dan Kelautan., 7(2): 121-124.

Marzuki, M. and Setyono, B.D.H. (2021). Growth dan Survival Rate of Vaname Shrimp (*Litopenaeus vannamei*) PL-10 on Different Stocking Density. Aquasains. 9(2):903-912.

Masriqah, N.; Aslamsyah, S. and Zainuddin. (2019). Feed Nutrient Retention at Various Doses of Sweet Potato (*Ipomea batatas*) in Feed as Prebiotic for Lactobacillus sp. in White Shrimp (*Litopenaeus vannamei*). Prosiding Simposium Nasional Kelautan dan Perikanan VI.

Novriadi, R.; Suwendi, E. and Tan, R. (2021). Aquaculture The Use Of Corn Distiller's Dried Grain With Solubles As A Protein Source In Practical Diets For Pacific White Leg Shrimp Litopenaeus Directorate General of Aquaculture. In *Aquaculture*.

Nuhman. (2009). The effect of feed percentage on the survival and growth rate of vannamei shrimp (*Litopenaeus vannamei*). Jurnal Ilmiah Perikanan dan Kelautan. 1(2):193-197.

Oliveira, K. R. B.; Segura, J. G.; Oliveira, B. A.; Medeiros, A. C. L.; Zimba, R. D. and Viegas, E. M. M. (2020). Distiller's Dried Grains with Solubles In Diets for Pacu, *Piaractus mesopotamicus* juveniles: Growth Performance, Feed Utilization, Economic Viability, and Phosporus Release. Journal of Animal Feed Science and Technology. 262:1-10.

Pamungkas, W. (2013). Palatability Test of Palm Kernel Flour Hydrolyzed with Rumen Enzymes and Effect on Growth Response of Siamese Catfish Seeds (*Pangasius hypophthalmus* Sauvage). Berita Biologi. 12(3):359-366.

Purnamasari, I.; Purnama, D. and Utami, M. A. F. (2017). Growth of Vaname Shrimp (*Litopenaeus vannamei*) in Intensive Ponds. Jurnal Erlangga. 2(1):58-67.

Qiu, X.; Tian, H. and Davis, D. A. (2017). Evaluation of a high protein distiller's dried grains product as a protein source in practical diets for Pacific white shrimp *Litopenaeus vannamei*. *Aquaculture*, *480*(July), 1–10. https://doi.org/10.1016/j.aquaculture.2017.07.038

Rhodes, M. A.; Yu, D.; Zhou, Y. and Davis, D. A. (2015). Use of lipid-extracted distillers dried grain with solubles (DDGS) in diets for pacific white shrimp. *North American Journal of Aquaculture*, *77*(4), 539–546. https://doi.org/10.1080/15222055.2015.1067263

Riyanti; Supono and Santoso, L. (2020). Growth Performance of Whiteleg Shrimp Postlarvae (*Litopenaeus vannamei)* Fed with Frozen Artemia and Decapsulated Artemia. Jurnal Akuakultur Rawa Indonesia. 8(1):70-83.

Rolin, F.; Setiawai, M. and Jusadi, D. (2015). Evaluation of the Administration of Cinnamon Leaf Extract (*Cinnamomum burmannii*) in Feed on the Growth Performance of Catfish (*Pangasianodon hypophthalmus* Sauvage, 1878). Jurnal Ikhtiologi Indonesia. 15(3) : 201-208.

Sandor, Z. J.; Revesz, N.; Lefler, K. K.; Colovic, R.; Banjac, V. and Kumar, S. (2021). Potential of Corn Distiller's Dried Grains with Solubles (DDGS) in the Diet of European Catfish (*Silurus glanis*). Aquaculture Reports., 20:1-11.

Setiawari, J.E.; Tarsim; Adiputra, Y.T. and Hubaidah, S. (2013). The Effect of Adding Probiotics to Feed with Different Doses on Growth, Survival, Feed Efficiency and Protein Retention of Catfish (*Pangasius hypophthalmus*). Jurnal Rekayasa dan Teknologi Budidaya Perairan. 1(2):151-162.

SNI. (2014). Udang Vaname (*Litopenaeus vannamei*, Boone 1931). Badan Standardisasi Nasional. Jakarta. 11 hlm.

Sudrajat, A.O. and Effendi, I. (2002). Providing Artificial Feed for Betutu Fish Seed *Oxyeleotris marmorata* (BLKR). Jurnal Akuakultur Indonesia. 1(3):109-118.

Suprayudi, M. A.; Deswira, U. and Setiawati, M. (2013). The use of DDGS (Distillers Dried Grain with Solubles) corn as a source of vegetable protein for gourami fish seed feed *Osphronemus goramy* Lac. Jurnal Ikhtiologi Indonesia. 13(1): 25-34.

Suri, R.; Putri, B. and Susanti, O. (2018). Study on the Use of Commercial Feed Mixed with *Bacillus coagulans* Bacteria on the Performance of *Litopenaeus vannamei*. E-Jurnal Rekayasa dan Teknologi Budidaya Perairan. 7(1) : 751-761.

Tacon, A. G. J. (1987). *The Nutrition and Feeding of Farmed Fish and Shrimp-A Trainingb Mannual*. FAO of the United, Brazil. 106-109 pp.

Ulumiah, M.; Lamid, M.; Soepranianondo, K.; Al-arif, M. A.; Alamsjah, M. A. and Soeharsono. (2020). Feed Management and Analysis of Vaname Shrimp Cultivation Business (*Litopanaeus vannamei*) at Different Locations in Bangkalan Regency and Sidoarjo Regency. Journal of Aquaculture and Fish Health. 9(2):95-103.

Wawoh, L. A.; Durand, S. S. and Tambani, G. O. (2019). Financial Analysis of Vaname Shrimp Cultivation Business at the Fisheries Training and Extension Center (BPPP) Aertembaga, Bitung City, North Sulawesi Province. Akulturasi. 7(1): 1135-1142.

Weatherly, A. H. (1972). *Growth and Ecology of Fish Population*. Academic Press: New York. 175 pp.

Witoko, P.; Purbosari, N.; Noor, N. M.; Hartono, D. P.; Barades, E. and Bokau, R. J. (2018). Vaname Shrimp Cultivation (*Litopennaeus vannamei*) in Floating Marine Net Cages. Prosiding Seminar Nasional Pengembangan Teknologi Pertanian. Hlm 410-418.

Zonneveld, N.; Huisman, E.A. and Boon, J.H. (1991). Prinsip-Prinsip Budidaya Ikan. PT Gramedia Pustaka Utama:Jakarta. 318 hlm.