2021_2nd Icard_Mas Bayu

by Achmad Noerkhaerin Putra

IOP Conference Series: Earth and Environmental Science

PAPER · **OPEN ACCESS**

Combination of fish oil with rubber seed oil to the growth performance of catfish (*Clarias* sp.)

To cite this article: M B Syamsunarno *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **715** 012049

IOP Conf. Series: Earth and Environmental Science **715** (2021) 012049 doi:10.1088/1755-1315/715/1/012049

Combination of fish oil with rubber seed oil to the growth performance of catfish (*Clarias* sp.)

M B Syamsunarno[1,2*], I D G Tambunan[1], A Munandar[1], Mustahal[1], A N Putra[1], M Herjayanto[1]

[1]Departement of Fisheries, Faculty of Agriculture, University of Sultan Ageng Tirtayasa Jalan Raya Jakarta Km. 04 Pakupatan, Serang City, Banten Province, Indonesia 42121
[2] Indonesia-Center of Excellence for Food Security (Local Food Innovation)
University of Sultan Ageng Tirtayasa. Jl. Raya Jakarta Km. 04 Pakupatan, Serang City, Banten Province, Indonesia, 42121

*email : masbayusy@untirta.ac.id

Abstract. The rubber seed oil contains essential fatty acids, which may be required by cultured freshwater fish. Therefore, the research aimed to determine a combination of fish oil and rubber seed oil for catfish's best growth performance (*Clarias* sp.). Isonitrogenous (33.23 ± 0.19%) and isoenergy (266.50 ± 0.09 DE kcal/100g) tested diets were used in the experiment. The fish oil was replaced by rubber seed oil at 0%, 15%, 25%, 35%, and 50%, respectively. Cyanide acid of rubber seed oil was reduced its content by stirring at 110 °C for 90 minutes to have as high as 0.47 ppm. Catfish fingerlings of 6.91 ± 0.04 g in individual weight were randomly distributed into 15 aquariums (60x40x40cm) each at a rate of 20 fingerlings and fed on the tested diet ad satiation for 40 days during the experimental period. The results showed that the increase in rubber seed oil to replace fish oil in the feed was not significantly different from the survival rate and nutrient retention in body catfish (P> 0.05). Furthermore, catfish were not poisoned by cyanide acid, indicated by catfish blood profile in the normal range at the end of rearing (P>0.05). The combination of fish oil and rubber seed oil by 50% gives optimal growth in catfish.

1. Introduction

Catfish require a nutritionally complete and balanced diet for growth. The quality of fish feed is determined by the nutrients available to support basic metabolic, health status, and optimal growth [1]. Lipid is one of the macronutrients that must be available in the feed that serves as a source of essential fatty acids, and if insufficient amounts in the feed, it can reduce the use of protein as an energy source [2]. Fish oil is a major component of fat in food because of its complete fatty acid profile and can be a source of fish's metabolic energy [3]. However, its use is currently limited to meet the growing demand for the aquafeed industry [4]. That leads to increased feed prices affecting profit freshwater fish farmers, especially in catfish [5].

Vegetable oil is a potential source of lipid to replace fish oil in the diet because of its abundant availability, acceptable price, relatively low organic contamination, and high fatty acid [6]. Furthermore, types of agro-industrial by-products have the potential as alternative feed ingredients [7]. Rubber seed is a by-product in rubber cultivation that has not been utilized, with an oil content of around 40 - 50%

[8]. Rubber seed oil is a by-product of processing rubber seed meal, and it is estimating that rubber seed oil production in Indonesia is in the range of 192.2 - 199.08 million tons per year [10].

Rubber seed oil is a semi-drying oil containing essential fatty acids, namely, oleic acid (22.95%), linoleic acid (37.28%), and linolenic acid (19.22%) [10]. Similarly, the result was found by [11], who reports that oleic acid levels, linoleic acid, and linolenic acid were 25.33%, 37.50%, and 14.21%, respectively. The rubber seed oil has a higher fatty acid than soybean oil [12] and almost close to corn oil's fatty acid composition [13]. The rubber seed oil's essential fatty acid composition is 52% of the fatty acid composition [14].

Unprocessed rubber seed oil in the diet will limit feed intake, lower growth and survival rates, affecting blood profiles of fish [9] [15]—that is thought to be due to an anti-nutritional substance in cyanide acid-containing rubber seed oil. The most prominent anti-nutritional content in rubber seeds is cyanide acid [16]. There are also phytic, oxalic, tannin, saponins, and trypsin inhibitors [17] [18]. Several studies have reported that cyanide acid content can reduce through physical treatment, including soaking, heating, boiling, and roasting [19] [20]. Furthermore, [21] reported that stirring at 100°C could reduce cyanide acid in rubber seed oil. Therefore, the research aimed to determine a combination of fish oil and rubber seed oil for catfish's best growth performance (*Clarias* sp.).

2. Material and Methods

2.1. Rubber seed oil preparation

The number of 18 kg of rubber fruit was taken from smallholder plantations in Semerangkai Village, Sanggau Regency, West Kalimantan, and broken down to get a seed. The rubber seed was then boiled for 20 minutes, dried in an oven at 60°C for 60 minutes, and ground into meal form. The meal was oiled out using a pressing machine at 80°C for 30 minutes [22]. Cyanide acid of rubber seed oil was reduced its content by stirring at 110°C for 90 minutes to have as high as 0.47 ppm. [23] recommends that cyanide acid content in food products is 1 ppm. The process of removal of cyanide acid refers to [21].

2.2. Preparation experimental diet

Isonitrogenous (33.23 ± 0.19%) and isoenergy (266.50 ± 0.09 DE kcal/100g) tested diets were used in the experiment. The primary sources of protein in the experimental diet were fish meal and soybean meal. The total lipid in the test diet was 5% [24], from a combination of fish oil and rubber seed oil, namely 0%, 15%, 25%, 35%, and 50%. Raw materials are weighed according to the formula and mixed evenly and molded-in pellets with a 3 mm diameter, then oven at 60°C [9]. After drying, the experimental diet was put into a plastic bag labeled, and the samples were taken as the subject of proximate and fatty acid analysis. The formulation and analysis results of the experimental diets are present in Table 1 [25].

2.3. Experimental design

Catfish of 6.91 ± 0.04 g/fish in initial weight were reared at 20 individuals/aquarium. The fishes were raised in 15 aquariums of 60 x 40 x 40 cm in dimension size, each for 40 days. After acclimatized for seven days, the fish was fasted for 24 hours to eliminate the body's remaining feed [26]. Feeding was carried out three times a day at satiation. Water changes were carried out as much as 50% of the aquarium's total volume, aiming to maintain water quality during the study. At harvest, several fish samples were taken as subjects for proximate analysis and blood profiles.

2.4. Growth parameters

At the end of the study, the growth parameters of catfish were analyzed. The specific growth rate (SGR), feed efficiency (FE), survival rate (SR), and protein/lipid retention (PR/LR) were calculated using the formula according to [25].

$$SGR (\%) = 100 \times (\ln W_t - W_o) / time (days) \quad (1)$$
$$FE (\%) = 100 \times [wet weight gain (g) / dry feed intake (g)] \quad (2)$$
$$SR (\%) = NT/N0 \times 100 \quad (3)$$
$$PR/LR (\%) = ((F - I) / P) \times 100 \quad (4)$$

Where W_t and W_o indicate the final and initial weight (g), respectively, NT is the number of fish at the end (individuals), N0 is the number at the beginning (individuals). F is total protein/lipid in the final body (g), I is the total protein/lipid in the initial body (g), and P is total protein/lipid consumption (g).

Table 1. Composition of tested diets, and their proximate analysis and fatty acids

Composition	Experimental diet (%)				
	0	**15**	**25**	**35**	**50**
Fish meal	30.00	30.00	30.00	30.00	30.00
Soybean meal	27.50	27.50	27.50	27.50	27.50
Tapioca	13.00	13.00	13.00	13.00	13.00
Pollard	9.45	9.45	9.45	9.45	9.45
Wheat flour	7.50	7.50	7.50	7.50	7.50
Fish oil	5.00	4.25	3.75	3.25	2.50
Rubber seed oil	0.00	0.75	1.25	1.75	2.50
Vitamin and mineral premix	5.00	5.00	5.00	5.00	5.00
Casein	2.00	2.00	2.00	2.00	2.00
Vitamin C	0.05	0.05	0.05	0.05	0.05
PMC	0.10	0.10	0.10	0.10	0.10
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Proximate compositions (dry base)					
Crude protein (%)	33.07	33.16	33.48	33.39	33.06
Crude lipid (%)	6.43	6.56	6.46	6.44	6.45
Ash (%)	13.62	13.92	13.80	13.74	13.63
Crude fiber (%)	7.44	7.45	7.41	7.42	7.48
Free extract nitrogen (%)	39.44	38.91	38.85	39.01	39.38
DE (kcal/100g)*	266.43	266.47	266.63	266.55	266.41
Fatty acids (%)					
Σ SFA**	18.72	18.59	18.51	18.42	18.29
Σ MUFA***	19.84	19.57	19.38	19.20	18.92
Σ n-6	20.46	20.71	20.88	21.05	21.31
Σ n-3	10.83	10.65	10.53	10.40	10.22
Σ n-3/ Σ n-6	0.53	0.51	0.50	0.49	0.48

Noted: * DE= Digestible energy = 1 g protein: 3.0 kkal DE; 1 g lipid: 8.1 g kkal DE; 1 g carbohydrate: 2.5 kkal DE [27]
** SFA= Saturated fatty acids
*** MUFA = Monounsaturated fatty acids

2.5. *Blood profiles*

At harvest, three individuals from each treatment were taken out for collecting blood samples of fish. The blood samples were taken out using a syringe already containing anti-coagulant 0.1 mL of 3.8% Na citrate [28]. Furthermore, the blood profile consisting of total red blood cells (RBC), white blood cells (WBC), haemoglobin, and haematocrit were calculated with a microscope's aid. Determination of total

IOP Conf. Series: Earth and Environmental Science **715** (2021) 012049 doi:10.1088/1755-1315/715/1/012049

RBC and WBC according to the method [29], measurement of haemoglobin (Hb) levels by the Sahli method according to [30], and measure of haematocrit (Ht) levels according to the procedure [31].

2.6. *Chemical analysis*

The proximate composition of raw materials, experimental diet, and fish body samples were analyzed according to the standard method [32]. The proximate composition is crude protein, crude fat, ash content, crude fiber, and nitrogen-free extract.

2.7. *Statistical analysis*

Statistical analysis of growth parameters and blood profiles perform using the Statistical Package for the Social Sciences (SPSS) program for Windows (v.16.0). If a significant difference, then proceeds with the Tukey test at a level of 95% [33].

3. Results and Discussion

Based on the results of the research in Table 2, it was known that the increase in rubber seed oil in feed to replace fish oil could increase feed intake in catfish (P< 0.05). This increase is thought to be due to rubber seed oil, which can increase feed palatability. Similar results are reported in juvenile Malaysian mahseer (*Tor tambroides*) fed a vegetable oil-based feed to replace fish oil [34]. Unsaturated fatty acids influence feed palatability. According to [15], the decrease of unsaturated fatty acids results in poor taste and the feed aroma, limiting feed intake by fish. In this study, the unsaturated fatty acid content in the test feed (Table 1) is thought to have increased feed consumption.

Table 2. The growth performance of catfish fed the experimental diet during the rearing period

Parameters**	Experimental diet (%)*				
	0	15	25	35	50
FI (g)	165.00±3.61^{a}	167.33±4.04^{a}	176.67±5.51^{ab}	181.67±5.86^{b}	183.67±2.08^{b}
FE (%)	40.31±1.78^{a}	41.35±2.87^{ab}	44.56±5.86^{ab}	49.08±2.80^{ab}	49.08±1.58^{b}
SGR (%)	1.00±0.06^{a}	1.03±0.06^{a}	1.14±0.12^{ab}	1.24±0.03^{b}	1.30±0.05^{b}
Protein retention (%)	67.09±2.44	67.61±2.72	71.59±2.84	72.40±3.14	73.95±3.41
Lipid retention (%)	64.03±5.34	62.42±3.21	63.12±5.62	64.05±5.33	65.61±5.02
SR (%)	96.67±2.89	96.67±2.89	98.33±2.89	100.00±0.00	96.67±2.89

Noted: *The values in the same row followed by similar superscript are not significantly different (p>0.05).
** feed intake (FI), feed efficiency (FE), specific growth rate (SGR), survival rate (SR)

The increased composition of rubber seed oil in the feed affects feed efficiency and can further increase growth. The results of statistical tests showed that the feed without rubber seed oil (0%) was significantly different on feed efficiency and specific growth rate at 50% treatment (P <0.05). The combination of fish oil with rubber seed oil as much as 50% produces an adequate supply of essential fatty acids to increase catfish growth. The use of vegetable oil to replace fish oil in aquafeed can be done more than 50% if the fatty acids found in the feed are sufficient to meet the needs of essential fatty acids in fish [4]. Based on Table 1, the n-6 fatty acids increased with the additional rubber seed oil in the diet. In general, freshwater fish need linoleic acid (18: 2n-6), or linolenic acid (18: 3n-3), or both to support optimum growth [1]. According to [35], catfish need more n-6 than n-3 fatty acids to accelerate their growth. The increasing growth of catfish is thought to be related to the decreasing ratio of n-3/n-6 in the diet. According to [36], the n-3 and n-6 fatty acid requirements in the lower n-3/n-6 rate promote better growth at the striped catfish (*Pangasius hypophthalmus*).

Protein and lipid retention at the end of the study had no significant effect with different ratios of rubber seed oil and fish oil (P> 0.05). The presence of saturated fatty acids in the appropriate test diet required by catfish causes the energy derived from these fatty acids to be used as an energy source to maintain the fish's body. According to [29], higher saturated fatty acids can be easily oxidized. The energy derived from these fatty acids can be used to maintain body maintenance and protein for growth. This study's results are following the results of a research according to [37] [36] [38].

Table 3. The value of blood profiles in catfish fed the experimental diet at the end of the study

Blood profile**	Experimental diet (%)*				
	0	15	25	35	50
RBC (x10^6 cell/mm^3)	1.49±0.14	1.56±0.12	1.56±0.11	1.55±0.13	1.57±0.13
RWC (x10^4 cell/ mm^3)	3.20±0.06	3.21±0.08	3.28±0.15	3.26±0.03	3.28±0.07
Hb (g%)	6.47±0.15	6.50±0.20	6.43±0.15	6.50±0.30	6.43±0.21
Ht (%)	25.60±0.44	25.40±0.17	25.83±0.31	25.73±0.65	25.47±0.31

Noted: *The values in the same row followed by similar superscript are not significantly different (p>0.05).
** red blood cell (RBC), white blood cell (WBC), Haemoglobin (Hb), Ht (Haematocrit)

Table 3 shows that the blood profiles did not significantly differ between treatments (P> 0.05). The level of cyanide acid will affect fish health and fish blood profile. According to [15], fish exposed to cyanide acid in their body causes the fish to be under metabolic stress, making it susceptible to disease. The process of cyanide acid poisoning in fish involves cellular cytochrome enzymes so that haemoglobin in the blood cannot bind to oxygen and causes low haemoglobin [39]. High cyanide acid will affect blood chemistry and blood profile, such as low haematocrit, low total red blood cells and white blood cells [40] [15]. The study results [9] reported a low fish survival rate due to high cyanide acid, but in this study, the survival rate was not different, namely between 96.67-100% (P>0.05). The content of cyanide acid of rubber seed oil used in this study can make tolerant of catfish. Cyanide acid below 5.05 ppm in the feed does not affect fish survival rate [41]. Reducing cyanide acid to fish tolerance levels can improve rubber seed oil quality combined with fish oil up to 50% (1:1). These results suggest that rubber seed oil can be used as an alternative source of vegetable oil mixed with fish oil in feed, such as corn oil and palm oil. The combination of fish oil and corn oil is the best as a lipid source in the diet [27] [1]. According to [4], the vegetable oils most commonly used for fish feed production include soybeans, corn, rapeseed, sunflower, palm oil and olive oil.

4. Conclusion

The best combination of fish oil and rubber seed oil at 1:1 (50%) in the diet composition resulted in catfish's optimal growth performance.

References

[1] Halver J E and Hardy W R 2002 *Fish Nutrition 3rd ed*. California: Academic Press
[2] Syamsunarno M B, Mokoginta I, and Jusadi D 2011 The effect of different energy-protein ratios in iso protein diet (30%) on the growth performance of *Pangasius hypophthalmus* fry *J. Ris. Akuakultur* **6** 1 pp. 63–70 doi: 10.15578/jra.6.1.2011.63-70.
[3] Rice R 2009 Nutritional value of fish oils in *Fish Oils* B. Rossel Ed. Chichester, UK: Blackwell pp. 131–154.
[4] Hodar A R, Vasava R, and Joshi N H 2020 Fish meal and fish oil replacement for aqua feed formulation by using alternative sources: a review *J. Exp. Zool. India* **23** 1 pp. 13–21
[5] Syamsunarno M B and Sunarno M T D 2016 Budidaya ikan air tawar ramah lingkungan untuk mendukung keberlanjutan penyediaan ikan bagi masyarakat in *Seminar Nasional Perikanan dan Kelautan 2016* pp. 1–16
[6] Ayisi C L, Zhao J, and Wu J W 2018 Replacement of fish oil with palm oil: Effects on growth performance, innate immune response, antioxidant capacity and disease resistance in Nile tilapia (*Oreochromis niloticus*) *PLoS One* **13** 4 pp. 1–17 doi:

10.1371/journal.pone.0196100.

[7] Suprayudi M A, Edriani G, and Ekasari J 2012 Quality evaluation of fermented products of various local agroindustrials by–product: The effect on digestibility and growth performance of common carp juvenile," *J. Akuakultur Indones.* **11** 1 pp. 1–10 doi: https://doi.org/10.19027/jai.11.1-10.

[8] Syamsunarno M B and Sunarno M T 2014 Study on rubber seed Hevea brasiliensis as a candidat of fish feed ingradient *J. Ilmu Pertan. dan Perikan.* **3** 2 pp. 135–142

[9] Shalihah H, Munandar A, and Syamsunarno M B 2019 Utilization of rubber seed oil in diet for supporting growth performance of common carp *Cyprinus carpio Depik* **8** 1 pp. 26–35 doi: 10.13170/depik.8.1.13100.

[10] Salimon J, Abdullah B M, and Salih N 2012 Rubber (*Hevea brasiliensis*) seed oil toxicity effect and linamarin compound analysis *Lipids Health Dis.* **11** pp. 1–8 doi: 10.1186/1476-511X-11-74.

[11] Aigbodion A I and Bakare I O 2005 Rubber seed oil quality assessment and authentication *JAOCS, J. Am. Oil Chem. Soc.* **82** 7 pp. 465–469 doi: 10.1007/s11746-005-1095-0.

[12] Ramadhas A S, Jayaraj S, and Muraleedharan C 2005 Biodiesel production from high FFA rubber seed oil *Fuel* **84** 4 pp. 335–340 doi: 10.1016/j.fuel.2004.09.016.

[13] Hwang J 2009 Diets with corn oil and/or low protein increase acute acetaminophen hepatotoxicity compared to diets with beef tallow in a rat model *Nutr. Res. Pract.* **3** 2 p. 95 doi: 10.4162/nrp.2009.3.2.95.

[14] Onoji S E, Iyuke S E, and Igbafe A I 2016 *Hevea brasiliensis* (rubber seed) oil: extraction, characterization, and kinetics of thermo-oxidative degradation using classical chemical methods *Energy and Fuels* **30** 12 pp. 10555–10567 doi: 10.1021/acs.energyfuels.6b02267.

[15] Komariyah S, Suprayudi M A, and Jusadi D 2014 Preliminary study of rubber seed *Hevea brasiliensis* oil utilization for tilapia diet *J. Akuakultur Indones.* **13** 1 pp. 61–67 doi: 10.19027/jai.13.61-67.

[16] Oluodo L A, Huda N, and Komilus C F 2018 Potential utilization of rubber seed meal as feed and food potential utilization of rubber seed meal as feed and food," *Int. J. Eng. Technol.* **4** 43, pp. 66–71 doi: http/doi:10.14419/ijet.v7i4.43.25821.

[17] Eka H D, Aris Y T, and Nadiah W A W 2010 Potential use of Malaysian rubber (*Hevea brasiliensis*) seed as food, feed and biofuel *Int. Food Res. J.* **17** 3, pp. 527–534

[18] Aguihe P C, Kehinde A S, Ospina-rojas C I, and Murakami A E 2017 Evaluation of processing methods of rubber (*Hevea brasiliensis*) seed meal for use as a feed ingredient for broiler chickens *J. Poult. Res.* **14** 1 pp. 20–27

[19] Karima R 2015 The soaking and boiling effect of HCN content in the rubber seed *J. Ris. Ind. Has. Hutan* **7** 1 p. 39 doi: 10.24111/jrihh.v7i1.855.

[20] Udo M D, Ekpo U, and Ahamefule F O 2018 Effects of processing on the nutrient composition of rubber seed meal *J. Saudi Soc. Agric. Sci.* **17** 3 pp. 297–301 doi: 10.1016/j.jssas.2016.06.001.

[21] Agustiar Y, Pato U, and Ali A 2018 Variation of water temperature in the agitation on the cyanide content and quality of rubber seed oil (*Havea brasiliensis*) *JOM Faperta* **5** 1 pp. 1–14

[22] Santoso H, Iryanto, and Inggrid M 2014 Effects of temperature, pressure, preheating time and pressing time on rubber seed oil extraction using hydraulic press *Procedia Chem.* **9** pp. 248–256 doi: 10.1016/j.proche.2014.05.030.

[23] Badan Standardisasi Nasional 2006 *Bahan Tambahan Pangan, Persyaratan Perisa dan Penggunaan Dalam Produk Pangan (SNI 01-7152-2006)*. Jakarta: Badan Standardisasi Nasional Indonesia

[24] Badan Standardisasi Nasional 2006 *Pakan Buatan untuk Ikan Lele (Clarias gariepinus)*. Jakarta: Badan Standardisasi Nasional Indonesia

[25] Nates S F 2016 *Aquafeed Formulation* Oxford: Elsevier Inc

[26] Putra A N *et al*. 2019 The utilization of vegetable waste silage as feed ingredient in diets for tilapia *Oreochromis niloticus* in *IOP Conference Series: Earth and Environmental Science* **383** p. 012002 doi: 10.1088/1755-1315/383/1/012002.

[27] National Research Council 2011 *Nutrient Requirements of Fish and Shrimp*. Washington DC: Academic Press

[28] Putra A N, Syamsunarno M B, Ningrum W, Jumyanah, and Mustahal 2020 Effect of the administration of probiotic bacillus NP5 in the rearing media on water quality, growth, and disease resistance of african catfish (*Clarias gariepinus*) *Biodiversitas*, **21** 6 pp. 2566–2575, doi: 10.13057/biodiv/d210629.

[29] Blaxhall P C and Daisley K W 1973 Routine hematological methods for use with fish blood *J Fish Biol*. **5** pp. 771–781

[30] Wedemeyer G A and Yasutake 1977 *Clinical methods for the assessment on the effect of environmental stress on fish health*. US: U.S Fish and Wildlife Service

[31] Anderson D P and Siwicki A K 1995 Basic hematology and serology for fish health program," in *Proceeding of the second symposium on disease in Asian aquaculture, October 25-29*

[32] Association of Official Analytical Chemists 2012 *Official methods of analysis 19th ed*. Airlington: Association of Official Analytical Chemists

[33] Aqil M and Efendi R 2013 *Aplikasi SPSS dan SAS Untuk Perancang Percobaan*. Yogyakarta: Absolute Media

[34] Kamarudin M S, Ramezani-Fard E, Saad C R, and Harmin S A 2012 Effects of dietary fish oil replacement by various vegetable oils on growth performance, body composition and fatty acid profile of juvenile Malaysian mahseer, *Tor tambroides Aquac. Nutr*. **18**, 5 pp. 532–543, 2012, doi: 10.1111/j.1365-2095.2011.00907.x.

[35] Juliana B R, Vanessa B V, Tatiana E, Claudia S R, and Bernardo B 2016 Fatty acid composition of fillets of silver catfish fed on sunflower oil and linseed oil *Int. Food Res. J*. **23** 6 pp. 2453–2458

[36] Asdari R, Aliyu-Paiko M, Hashim R, and Ramachandran S 2011 Effects of different dietary lipid sources in the diet for *Pangasius hypophthalmus* (Sauvage, 1878) juvenile on growth performance, nutrient utilization, body indices and muscle and liver fatty acid composition *Aquac. Nutr*. **17** 1 pp. 44–53 doi: 10.1111/j.1365-2095.2009.00705.x.

[37] Ng W K, Lim P K, and Boey P L 2003 Dietary lipid and palm oil source affects growth, fatty acid composition and muscle α-tocopherol concentration of African catfish, *Clarias gariepinus Aquaculture* **215** 1–4, pp. 229–243 doi: 10.1016/S0044-8486(02)00067-4.

[38] Sun S, Ye J, Chen J, Wang Y, and Chen L 2011 Effect of dietary fish oil replacement by rapeseed oil on the growth, fatty acid composition and serum non-specific immunity response of fingerling black carp, *Mylopharyngodon piceus Aquac. Nutr*. **17** 4 pp. 441–450 doi: 10.1111/j.1365-2095.2010.00822.x.

[39] Dube P N and Hosetti B B 2010 Behavior surveillance and oxygen consumption in the freshwater fish *Labeo rohita* (Hamilton) exposed to sodium cyanide *Biotechnol. Anim. Husbandry*. **26** 1–2 pp. 91–103, doi: 10.2298/bah1002091d.

[40] Borin K, Lindberg J E, and Ogle R B 2005 Effect of variety and preservation method of cassava leaves on diet digestibility by indigenous and improved pigs *Anim. Sci*. **80** 3 pp. 319–324 doi: 10.1079/ASC41560319.

[41] Fawole F J *et al*. 2016 Nutritional evaluation of protein isolate from rubber seed in the diet of *Labeo rohita*: Effects on growth performance, nutrient utilization, whole body composition and metabolic enzymes activity *Anim. Feed Sci. Technol*. **219** pp. 189–199 doi: 10.1016/j.anifeedsci.2016.06.014.

Acknowledgments
We are grateful to Research Institutions and Community Service (LPPM) and Faculty of Agriculture University of Sultan Ageng Tirtayasa for shared the grant research with the scheme “Penelitian Dosen Madya (PDM).”

2021_2nd Icard_Mas Bayu

ORIGINALITY REPORT

18%	13%	14%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	biodiversitas.mipa.uns.ac.id Internet Source	1%
2	Andika Gumilang Kushayadi, Muhammad Agus Suprayudi, Dedi Jusadi, Ichsan Achmad Fauzi. " Evaluation of rubber seed oil as lipid source in red tilapia (sp.) diet ", Aquaculture Research, 2019 Publication	1%
3	journal.ipb.ac.id Internet Source	1%
4	kindai.repo.nii.ac.jp Internet Source	1%
5	Submitted to Universitas Airlangga Student Paper	1%
6	lib.unisayogya.ac.id Internet Source	1%
7	www.cambridge.org Internet Source	1%
8	Submitted to Universiti Sains Malaysia Student Paper	

		1%
9	evols.library.manoa.hawaii.edu Internet Source	1%
10	Nattaya Lourith, Mayuree Kanlayavattanakul, Apirada Sucontphunt, Thunnicha Ondee. "Para Rubber Seed Oil: New Promising Unconventional Oil for Cosmetics", Journal of Oleo Science, 2014 Publication	<1%
11	coek.info Internet Source	<1%
12	diposit.ub.edu Internet Source	<1%
13	www.tandfonline.com Internet Source	<1%
14	Abbas Zamani, Maryam Khajavi, Aboozar Moafi, Enric Gisbert. " Utilization of grape seed oil as a dietary lipid source in rainbow trout ( ) diets ", Journal of Applied Aquaculture, 2020 Publication	<1%
15	Kamalakar, K., Amit Kumar Rajak, R.B.N. Prasad, and M.S.L. Karuna. "Rubber seed oil-based biolubricant base stocks: A potential	<1%

source for hydraulic oils", Industrial Crops and Products, 2013.
Publication

16 Wira Wisnu Wardani, Alimuddin Alimuddin, Muhammad Zairin Junior, Mia Setiawati, Sri Nuryati, Muhammad Agus Suprayudi. " Growth performance, fillet quality and immunity after challenge with of red tilapia (.) fed diet containing cysteamine and creatine ", Aquaculture Research, 2021
Publication
<1%

17 Yang, Qi-hui, Bei-ping Tan, Xiao-hui Dong, Shu-yan Chi, and Hong-yu Liu. "Effects of different levels of Yucca schidigera extract on the growth and nonspecific immunity of Pacific white shrimp (Litopenaeus vannamei) and on culture water quality", Aquaculture, 2015.
Publication
<1%

18 journalarticle.ukm.my
Internet Source
<1%

19 researchonline.jcu.edu.au
Internet Source
<1%

20 www.science.gov
Internet Source
<1%

21 Gang Yang, Wenhao Jiang, Yunfei Chen, Yi Hu, Qiubai Zhou, Mo Peng, Mingren Qu, Vikas Kumar. " Effect of oil source on growth
<1%

performance, antioxidant capacity, fatty acid composition and fillet quality of juvenile grass carp ( ) ", Aquaculture Nutrition, 2020
Publication

22	www.fisheriesjournal.com Internet Source		<1 %
23	Anurak Khieokhajonkhet, Sutinun Muichanta, Niran Aeksiri, Khanitta Ruttarattanamongkol, Jiraporn Rojtinnakorn, Gen Kaneko. "Evaluation of sacha inchi meal as a novel alternative plant protein ingredient for red hybrid tilapia (Oreochromis niloticus×O. mossambicus): Growth performance, feed utilization, blood biochemistry, and histological changes", Animal Feed Science and Technology, 2021 Publication		<1 %
24	Majid Nikzad Hassankiadeh, Hossein Khara, Mohammad A. Yazdani Sadati, Hossein Parandavar. "Effects of dietary fish oil substitution with mixed vegetable oils on growth and fillet fatty acid composition of juvenile Caspian great sturgeon (Huso huso)", Aquaculture International, 2012 Publication		<1 %
25	jurnal-iktiologi.org Internet Source		<1 %

repositorio.unesp.br

26	Internet Source	<1 %
27	www.enreco.com Internet Source	<1 %
28	www.fisheriessciences.com Internet Source	<1 %
29	www.globalscientificjournal.com Internet Source	<1 %
30	Ahmad, Junaid, Suzana Yusup, Awais Bokhari, and Ruzaimah Nik Mohammad Kamil. "Biodiesel Production from the High Free Fatty Acid *“Hevea brasiliensis”* and Fuel Properties Characterization", Applied Mechanics and Materials, 2014. Publication	<1 %
31	Bashar Mudhaffar Abdullah, Jumat Salimon. "Toxicity Study of Malaysian Rubber (Hevea brasiliensis) Seed Oil as Rats and Shrimps Tests", Asian Journal of Biochemistry, 2010 Publication	<1 %
32	Fawole, Femi John, Narottam Prasad Sahu, K.K. Jain, Subodh Gupta, N. Shamna, Vikas Phulia, and D.L. Prabu. "Nutritional evaluation of protein isolate from rubber seed in the diet of Labeo rohita: Effects on growth performance, nutrient utilization, whole body	<1 %

composition and metabolic enzymes activity", Animal Feed Science and Technology, 2016.
Publication

33	Houguo Xu, Giovanni M. Turchini, David S. Francis, Mengqing Liang, Thomas S. Mock, Artur Rombenso, Qinghui Ai. "Are fish what they eat? A fatty acid's perspective", Progress in Lipid Research, 2020 Publication	<1%
34	J.W. Hong, S.H. Lee, M. Moniruzzaman, Y. Park, S.H. Won, H.Y. Jo, S.S.O. Hung, S.C. Bai. " Dietary eicosapentaenoic acid requirement of juvenile rock bream, ", Aquaculture Nutrition, 2018 Publication	<1%
35	Wenqiang An, Xiaohui Dong, Beiping Tan, Meihuan Wu, Shuang Zhang, Shuyan Chi, Qihui Yang, Hongyu Liu, Yuanzhi Yang. " Effects of dietary vegetable oil on growth performance, digestive capacity, antioxidant capacity and expression of immune - related genes in the hybrid grouper (♀ × ♂) ", Aquaculture Nutrition, 2020 Publication	<1%
36	e-journal.unair.ac.id Internet Source	<1%
37	ir-library.ku.ac.ke Internet Source	<1%

38 library.wur.nl
Internet Source
<1 %

39 link.springer.com
Internet Source
<1 %

40 ojs.omniakuatika.net
Internet Source
<1 %

41 peerj.com
Internet Source
<1 %

42 tesisenxarxa.net
Internet Source
<1 %

43 www.flku.jp
Internet Source
<1 %

44 E.M. Dantas, B.C.S. Valle, C.M.S. Brito, N.K.F. Calazans, S.R.M. Peixoto, R.B. Soares. " Partial replacement of fishmeal with biofloc meal in the diet of postlarvae of the Pacific white shrimp ", Aquaculture Nutrition, 2016
Publication
<1 %

45 Miao Yang, Wenlei Zhu, Hui Cao. "Biorefinery methods for extraction of oil and protein from rubber seed", Bioresources and Bioprocessing, 2021
Publication
<1 %

46 Puxvadee Chaikul, Nattaya Lourith, Mayuree Kanlayavattanakul. "Antimelanogenesis and cellular antioxidant activities of rubber (Hevea
<1 %

brasiliensis) seed oil for cosmetics", Industrial Crops and Products, 2017
Publication

47	Samuel E. Onoji, Sunny E. Iyuke, Anselm I. Igbafe. " (Rubber Seed) Oil: Extraction, Characterization, and Kinetics of Thermo-oxidative Degradation Using Classical Chemical Methods ", Energy & Fuels, 2016 Publication	<1%
48	Huang, F., M. Jiang, H. Wen, W. Liu, C. G. Yang, F. Wu, J. Tian, and Q.W. Wie. "Effects of different dietary lipid sources on growth performance, tissue fatty acid composition and serum lipid indices of juvenile Amur sturgeon, Acipenser schrenckii Brandt, 1869", Journal of Applied Ichthyology, 2014. Publication	<1%

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		

2021_2nd Icard_Mas Bayu

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9