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Research Article

Effect of Energy Sources and Tra Fish Oil in the Diet on Nutrient Digestibility and Methane Emissions of Fattening Beef Cattle

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Abstract | The objective of the study was to evaluate the effects of different energy feed sources and the inclusion of Tra fish oil (TrO) on feed intake, nutrient digestibility, and methane emissions in fattening beef cattle. Four Charolais crossbred steers (average body weight 333±19.5 kg) were used in a 4×4 Latin square design with a 2×2 factorial arrangement of treatments. Factor A was the carbohydrate source—maize (Ma) or cassava chips (Ca); Factor B was the inclusion of Tra fish oil—without or with TrO. The results indicated that maize-based diets tended to improve nutrient intake, digestibility, and weight gain compared to cassava-based diets, although differences were not statistically significant (P>0.05). The addition of TrO generally resulted in reduced nutrient intake, digestibility, and weight gain, again with no significant effect (P>0.05). Dry matter digestibility was highest in the MaNoTrO treatment (69.2%) and lowest in CaTrO (66.1%). Despite the reductions in performance parameters, TrO inclusion led to lower methane emissions. Specifically, the MaTrO treatment reduced methane emissions by 4.12% compared to MaNoTrO (86.1 vs. 89.8 MJ/kg DM intake), and CaTrO showed a 3.34% reduction compared to CaNoTrO (86.8 vs. 89.8 MJ/kg DM intake). Methane emissions were lowest in MaTrO, which also outperformed CaTrO in nutrient utilization and emission mitigation. No significant interaction between energy source and TrO inclusion was observed for feed intake, digestibility, or weight gain (P>0.05). The combination of maize and Tra fish oil (MaTrO) was most effective in reducing methane emissions while maintaining better nutrient utilization in fattening beef cattle. This suggests potential for integrating maize and fish oil to improve the environmental efficiency of beef production systems utilizing local by-products.

Keywords | Digestibility, Methane, Lipid, Nutrition, Combinations, Ruminants

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INTRODUCTION

Methanogenic production from long-term ruminant farming significantly impacts climate change, exacerbating the greenhouse effect and further disrupting the Earth's climate system. Ruminant farming is one of the agricultural sectors that emit greenhouse gases such as methane and carbon dioxide from the breakdown of complex carbohydrates by microorganisms in the rumen (Lesschen *et al*., 2011; Huhtanen *et al*., 2016). Reducing methane emissions from ruminant digestion of roughage contributes to environmental protection (Liu *et al*., 2019). Therefore, it is essential to prevent as many polluting emissions from agricultural production as possible (Siegford *et al*., 2008). Adding fat to ruminant diets is one way to increase the energy density of the diet. Furthermore, oil supplementation could adjust the rumen microbial ecosystem, leading to changes in fermentation processes. According to Vargas *et al*. (2020), adding vegetable oil to ruminant diets increased propionic acid formation and reduced methane emissions but did not affect feed digestion. Beauchemin *et al*. (2007) reported that adding fat to ruminant diets was one of the ways to reduce methane production.

Production of Catfish (*Pangasius hypophthalmus*) is most popular in the Mekong Delta of Vietnam. As a result, the byproduct of catfish oil (Tra fish oil) is available in large amounts. Thu and Dong (2021) suggested that Tra fish oil contains from 11.0 to 14.0% with high unsaturated fatty acids and metabolizable energy of 27.0 MJ/kg DM, supplemented with 3% dry matter intake tended to low methane emission on *in vitro* gas, which needs more study on beef cattle. According to Beauchemin *et al*. (2008), fat supplementation is considered a dietary option for mitigating enteric methane emissions. Haque (2018) also reported that less fermentation and CH_4 production will occur if the energy supplementation in a ruminant's diet is changed from carbohydrates to fat. However, the key factor in the design of diets for fattening cattle is the supply of energy from maize and cassava chips (Nghiep and Truong, 2024; Kabsuk *et al*., 2024). Recently, farmers have supplemented diets with various energy feeds such as rice bran, maize, and cassava, as well as homemade concentrated mixtures from these energy feeds in ruminant production (Dung, 2014).

Environmental friendliness is one factor that must be considered in sustainable agricultural production. Therefore, this study aimed to determine the effect of Tra fish oil as a supplement with feed energy sources in fattening beef cattle.

MATERIALS AND METHODS

Location and Time of Study

The experiment was carried out at the Hanh Cuong cattle farm, Chau Thanh district of An Giang province, Vietnam from August 2024 to November 2024.

Laboratory analyses were conducted at the E205 laboratory of the Department of Animal Science at the College of Agriculture, Can Tho University.

Experimental Design and Feeds

Four Charolais crossbred cattle bulls (Figure 1) with a body weight of 333±19.5 kg (21 months) were randomly assigned to a 2x2 factorial arrangement in a 4x4 Latin square design with four treatments. Factor A was the carbohydrate source, which included maize (Ma) and cassava chip (Ca), while Factor B was related to Tra fish oil (Figure 2), being without or with Tra fish oil suggested by Thu and Dong (2021). The nutrition of Tra fish oil (%DM) in this study was analyzed as 98.6% dry matter, 99.2% organic matter, and 99.8% ether extract. The chemical composition of feeds is presented in Table 1. The sources of carbohydrates and two levels of Tra fish oil are shown in Table 2.

Figure 1: The Charolais crossbred cattle.

Figure 2: Tra fish oil.

Table 1: Chemical composition of feeds.

Feeds	DM	In DM%			
		OM	CP	NDF	ADF
Maize	85.4	97.0	8.09	20.6	4.03
Cassava chip	84.7	96.3	3.48	16.1	3.83
Broken rice	85.3	99.5	7.59	8.98	3.34
Soybean meal	87.0	93.6	44.1	15.2	11.0
Elephant grass	16.3	90.5	8.66	60.6	38.3
Rice straw	83.3	88.9	5.88	68.7	44.6
Urea	99.6	-	286	-	-

DM: dry matter; **OM:** organic matter; **CP:** crude protein; **NDF:** neutral detergent fiber; **ADF:** acid detergent fiber.

Table 2: Ingredients of diet used in the experiment.

Ingredients (%DM)	Ma		Ca	
	TrO	No TrO	TrO	No TrO
Maize	15.0	15.0	-	-
Cassava chip	-	-	15.0	15.0
Trafish oil	3.00	-	3.00	-
Broken rice	15.0	15.0	15.0	15.0
Soybean meal	5.00	5.00	5.00	5.00
Elephant grass	20.0	20.0	20.0	20.0
Rice straw	40.5	43.5	40.3	43.3
Urea	0.80	0.80	1.00	1.00
Premix	0.70	0.70	0.70	0.70
Total	100	100	100	100

Ma: Maize; **Ca:** cassava chip; Ingredients of premix: Vitamin A, Vitamin D3, Vitamin E, ferrous sulfate, zinc oxide, copper sulfate, magnesium sulfate, manganese sulfate, Phytase, Bacillus subtilis, Pediococcus acidilactici, Calcium carbonate.

Measurements Taken

Feed and nutrient intakes: Before feeding, all the feed was weighed and supplied to the cattle. All supplements were fed twice at 7:00 am and 1:00 pm. In detail, first, Tra fish oil was given orally, Tra Fish oil was weighed into a glass bottle and poured into the cattle's mouth. Then, the maize and cassava chips were mixed with broken rice, soybean meal, urea, and premix supplements before feeding. The elephant grass was fed at 8:00 am. Rice straw was supplied ad libitum at 2:00 pm. Freshwater was provided *ad libitum*. Refused feeds were weighed each morning. The daily dry matter and nutrients intake were determined from feed intake minus remaining feed.

Chemical analysis: Feeds, refusals, feces, and urine were analyzed for nutrient composition. The method of AOAC (1990) was an analysis of dry matter (DM) and organic matter (OM). The nitrogen (N) in feed, refusals, feces, and urine was specified using the Kjeldahl procedures of AOAC (1990). However, acid detergent fiber (ADF) and neutral detergent fiber (NDF) were analyzed using the method of Van *et al.* (1991).

Energy intakes and methane emissions: The metabolizable energy (ME) in cattle diets was calculated by the suggestion of Bruinenberg *et al.* (2002).

$$ME\ (MJ/head/day) = 14.2 \times DOM + 5.9 \times DCP\ (with\ DOM/DCP < 7)$$

$$ME\ (MJ/head/day) = 15.1 \times DOM\ (with\ DOM/DCP > 7)$$

Here, DOM was the digestible organic matter, and DCP was the digestible crude protein.

Methane emissions was suggested by Mills *et al.* (2003).

$$Methane\ (MJ/day) = 1.06 + 10.27\ Dietary\ forage\ proportion + 0.87\ DMI.$$

Apparent nutrient digestibility: Each experimental period lasted three weeks: one week for adaptation, one for diet stabilization, and one for feces collection (McDonald *et al.*, 2010).

Daily weight gains (DWG): The Charolais crossbred cattle were weighed in the morning (two consecutive days) before feeding, at the beginning and end of each experimental period by using the electrical scale (Tru-Test, Limited Auckland, Newzealand).

Data Analysis

The data were analyzed according to a 2x2 factorial arrangement in a 4x4 Latin square design using the ANOVA Linear Model (GLM) of Minitab Reference Manual Release 20 (Minitab, 2021). The statistical model included terms for cattle, period, energy source, Tra fish oil level, and interaction between the energy source and Tra fish oil level. Tukey's pairwise comparisons (P<0.05) were applied to determine differences between treatments.

RESULTS AND DISCUSSIONS

Nutrient Intakes

The results of Table 3 indicate that the Tra fish oil (TrO) supplementation did not affect the DM, OM, CP, NDF, and ADF (kgDM/cattle/day or kgDM/100 kg BW) of the cattle (P>0.05).

Overall, the DM intake of the cattle fed with maize was numerically higher than that of the cassava chip diet. This could be probably explained by the fact that maize has a higher crude protein content than cassava chips (Table 1). The DM intake (kg/cattle/day) of CaNoTrO treatment was lower than MaNoTrO, CaTrO and MaTrO treatments (7.32, 7.53, 7.40 and 7.36 kg, respectively). The DM consumption per 100 kg BW was not different among groups (P>0.05). It was 2.08, 2.11, 2.07 and 2.06 kg/100 kg BW corresponding to MaTrO, MaNoTrO, CaTrO, and CaNoTrO treatments (Figure 3). The DM intake/100 kg BW of Ma and Ca was 2.10 and 2.06 kg DM (P>0.05); 2.07 and 2.08 corresponding to TrO and without TrO (P>0.05).

The results did not find any interaction in the consumption of DM/BW between Es (enegry sources) and TrO (P>0.05). Previous publications indicated that the effect of catfish oil supplementation on the DM intake of cattle was diverse: Dry matter intake was reduced by fish oil supplementation in cows (AbuGhazaleh *et al.*, 2002; Donovan *et al.*, 2000;

Table 3: Total nutrient intake of crossbred cattle by different treatments.

Items	Es		TrO		SEM	Es*TrO				SEM	P		
	Ma	Ca	TrO	NoTrO		MaTrO	MaNoTrO	CaTrO	CaNoTrO		Es	TrO	Es*TrO
Feed intake, kgDM/cattle/day													
Maize	1.12	-	0.558	0.559	0.047	1.12	1.12	-	-	0.066	0.001	0.985	0.985
Cassava chip	-	1.08	0.539	0.544	0.033	-	-	1.08	1.09	0.047	0.001	0.921	0.921
Tra fish oil	0.107	0.106	0.212	-	0.008	0.214	0.000	0.211	-	0.011	0.922	0.001	0.922
Broken rice	1.11	1.10	1.10	1.11	0.057	1.10	1.11	1.09	1.10	0.081	0.944	0.940	0.967
Soybean meal	0.374	0.372	0.372	0.374	0.019	0.374	0.375	0.370	0.374	0.027	0.940	0.936	0.964
Urea	0.056	0.071	0.065	0.063	0.003	0.057	0.057	0.072	0.071	0.005	0.005	0.743	0.805
Premix	0.053	0.052	0.052	0.053	0.003	0.052	0.053	0.052	0.053	0.004	0.954	0.942	0.976
Elephant grass	1.41	1.43	1.41	1.43	0.045	1.41	1.42	1.41	1.44	0.064	0.838	0.720	0.908
Rice straw	3.22	3.15	3.07	3.29	0.138	3.03	3.40	3.11	3.18	0.195	0.721	0.280	0.463
Nutrient intake, kgDM/cattle/day													
DM	7.44	7.36	7.38	7.42	0.251	7.36	7.53	7.40	7.32	0.355	0.811	0.901	0.721
OM	6.78	6.67	6.72	6.74	0.230	6.71	6.85	6.72	6.63	0.325	0.756	0.951	0.728
CP	0.81	0.80	0.80	0.71	0.031	0.80	0.82	0.80	0.80	0.044	0.772	0.783	0.933
NDF	3.47	3.38	3.34	3.51	0.112	3.34	3.61	3.35	3.42	0.158	0.571	0.301	0.549
ADF	2.11	2.08	2.04	2.15	0.070	2.02	2.19	2.06	2.10	0.099	0.775	0.289	0.53
Nutrient intake, kgDM/100 kg BW													
DM	2.10	2.06	2.07	2.08	0.043	2.08	2.11	2.07	2.06	0.061	0.550	0.885	0.762
OM	1.91	1.87	1.89	1.89	0.040	1.90	1.92	1.88	1.86	0.056	0.480	0.966	0.773
CP	0.229	0.224	0.225	0.228	0.007	0.23	0.23	0.22	0.23	0.010	0.653	0.757	0.928
NDF	0.980	0.946	0.940	0.986	0.019	0.95	1.01	0.93	0.96	0.026	0.212	0.101	0.474
ADF	0.595	0.581	0.573	0.603	0.012	0.573	0.62	0.57	0.59	0.02	0.426	0.098	0.449

DM: dry matter; **OM:** organic matter; **CP:** crude protein; **NDF:** neutral detergent fiber; **ADF:** acid detergent fiber; **Ma:** Maize; **Ca:** cassava chips; **Es:** enegry sources; **TrO:** Tra fish oil Es* TrO interaction; **BW:** body weight.

Whitlock *et al.*, 2002; Nhan *et al.*, 2007). Our study was similar to the result of Nhan *et al.* (2007), who reported that cattle tended to lower feed intake with oil in the first study period (0-30 days). Fat supplements decreased dry matter intake (P<0.05), especially when fish oil was included in the diet. Fish oil has been shown to reduce DMI (Donovan *et al.*, 2000; AbuGhazaleh *et al.*, 2002; Whitlock *et al.*, 2002). In contrast, Amorocho *et al.* (2009) reported that cattle diets added catfish oil or yellow grease increased the DM intake of cattle.

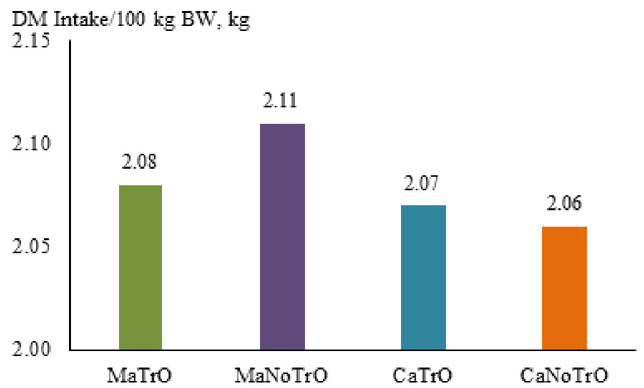

Figure 3: The DM Intake per 100 kg BW in the present study.

The value of CP intake was not various (P>0.05) between four treatments. It was 0.80, 0.82, 0.80 and 0.80 corresponding to MaTrO, MaNoTrO, CaTrO and CaNoTrO treatments. Both NDF and ADF intake were not different in this study.

Therefore, there were not found differences in nutrient intake consumption in interaction of Es*TrO during the present study (P>0.05).

Digestibility and Digestive Nutrient

Table 4 shows no differences among treatments for nutrient digestibility (P>0.05). Overall, the digestibility of diets with supplementation of TrO in DM, OM, CP, NDF, and ADF tended to be numerically lower than diets without supplementing TrO.As a result, energy feed from maize was better than cassava chips, and with oil was lower than without oil (Table 4). These agreed with the explanation of McDonald *et al.* (2010) that feed intake of ruminants is affected by feed composition and digestibility. However, it was not different in Es*TrO interaction. The DM digestibility (DMD) of MaTrO (67.3%) was lower than MaNoTrO (69.2%), and the DMD of CaTrO (66.1%) was lower

Table 4: Effect of carbohydrate sources and Tra fish oil on nutrient digestibility and digestive nutrient.

Items	Es		TrO		SEM	Es*TrO				SEM	P		
	Ma	Ca	TrO	NoTrO		MaTrO	MaNoTrO	CaTrO	CaNoTrO		Es	TrO	Es*TrO
Nutrient digestibility, %													
DM	68.2	67.2	66.7	68.7	1.160	67.3	69.2	66.1	68.3	1.630	0.535	0.241	0.935
OM	70.5	69.3	68.9	70.9	1.110	69.5	71.5	68.3	70.3	1.570	0.455	0.230	0.989
CP	73.7	74.4	72.2	75.9	1.380	71.9	75.4	72.5	76.3	2.370	0.763	0.149	0.943
NDF	67.4	65.6	65.0	68.0	1.560	66.4	68.4	63.6	67.5	2.210	0.425	0.205	0.678
ADF	61.9	60.0	59.0	62.9	1.290	59.6	64.2	58.4	61.7	1.830	0.335	0.053	0.732
Digestive nutrient, kgDM/100 kg BW													
DM	1.43	1.38	1.39	1.43	0.041	1.40	1.46	1.37	1.40	0.058	0.434	0.441	0.852
OM	1.35	1.30	1.30	1.34	0.038	1.32	1.37	1.28	1.31	0.053	0.357	0.496	0.822
CP	0.169	0.167	0.163	0.173	0.007	0.164	0.173	0.162	0.173	0.010	0.892	0.352	0.936
NDF	0.660	0.621	0.611	0.670	0.019	0.629	0.691	0.593	0.649	0.027	0.170	0.050	0.908
ADF	0.368	0.349	0.338	0.379	0.010	0.342	0.395	0.334	0.364	0.014	0.181	0.001	0.404

DM: dry matter; **OM:** organic matter; **CP:** crude protein; **NDF:** neutral detergent fiber; **ADF:** acid detergent fiber; **Ma:** Maize; **Ca:** cassava chips; **Es:** enegry sources; **TrO:** Tra fish oil Es* TrO interaction; **BW:** body weight.

than CaNoTrO treatment (68.3%) (Figure 4). The DM digestibility of Ma was higher than Ca, and TrO was lower than NoTrO treatment (68.2, 67.2, 66.7 and 68.7%, respectively). In addition, fatty acids can adhere to feed particles, thus building a physical barrier that prevents the action of microorganisms reported by Kaewpila *et al*. (2018).

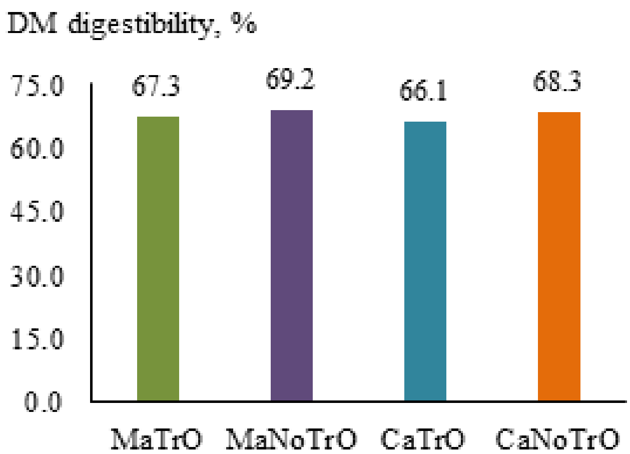

Figure 4: The DM digestibility in this study.

A possible explanation could be that Tra fish oil may coat fiber particles, inhibiting bacterial breakdown, or alter rumen bacteria, reducing fiber digestion efficiency. Additionally, high oil concentrations can alter the bacterial population in the rumen, making the bacteria less efficient at digesting fiber. This could lead to reduced fiber digestion and overall nutrient absorption. The explanation for the higher without oil compared with oil digestibility. According to Nhan *et al*. (2007), a higher oil level influenced the elimination of many protozoa in the rumen, probably related to protozoa engulfing and digesting bacteria. Moreover, Nhan *et al*. (2007) suggested that feed digestion by bacteria and fungi has compensated for those digested by protozoa. The previous publications indicated that cattle-fed fish oil-supplemented diets had lowered acetic and propionic acid content than those fed diets without fish oil supplementation (Ngu *et al*., 2019; Keady and Mayne, 1999). Moreover, this result agreed with Pimpa *et al*. (2021), who reported that the cattle supplemented with oil were less DM digestible than those fed without oil diets. The OM digestibility was similar to DMD. In addition, CP, NDF, and ADF digestibility were lower with oil than without oil. According to Kaewpila *et al*. (2018), medium- and long-chain fatty acids can hurt gram-positive rumen bacteria, including the cellulolytic bacteria *Ruminococcus sp.*, which could lead to the suppression of fiber digestibility.

For nutrient digestibility, the maize tended to be better than cassava; oil supplementation reduced digestible NDF and ADF (kg/100 kg BW), but this study's interaction between Es and TrO was not different.

Methane Emissions and Weight Gain

The result of Table 5 showed that the methane (CH_4) emission of MaNoTrO and CaNoTrO (89.8 and 89.8 MJ/kg DMI) was higher ($P>0.05$) than MaTrO and CaTrO treatment (86.1 and 86.8 MJ/kg DMI, respectively). The interaction of Es*TrO was not different in the study ($P>0.05$). In detail, the MaTrO was lower CH_4 per digestive dry matter (DDM) ($P>0.05$) compared to CaTrO treatment (128 and 132 MJ/kg DDM, respectively). Similarly, Ma had lower CH_4 emission per DOM ($P>0.05$) than Ca; No Oil was higher than Oil supplement for CH_4 emission per DOM ($P>0.05$) from Figure 5. The methane production was not significantly different in this study, which was

Table 5: Methane emissions and weight gain in cattle.

Items	Es		TrO		SEM	Es*TrO				SEM	P		
	Ma	Ca	TrO	NoTrO		MaTrO	MaNoTrO	CaTrO	CaNoTrO		Es	TrO	Es*TrO
Methane emissions													
CH_4, MJ/cattle/day	648	646	632	662	12.40	629	668	636	656	17.50	0.880	0.117	0.601
CH_4, MJ/100 kg BW/ day	184	181	176	187	6.470	179	188	178	185	9.140	0.782	0.398	0.905
CH_4, MJ/kg DMI	88.0	88.3	86.4	89.8	3.860	86.1	89.8	86.8	89.8	5.470	0.953	0.552	0.948
CH_4, MJ/kg DDM	129	132	130	131	7.150	128	131	132	132	10.10	0.794	0.928	0.876
CH_4, MJ/kg OMI	96.6	97.3	95.0	99.0	4.290	94.4	98.8	95.6	99.1	6.070	0.911	0.525	0.944
CH_4, MJ/kg DOM	137	141	138	140	7.550	136	139	141	141	10.70	0.739	0.884	0.890
Body weight, kg													
Initial BW, kg	348	351	350	348	9.510	347	348	354	349	13.50	0.788	0.890	0.850
Final BW, kg	362	364	361	364	11.10	360	364	363	365	15.80	0.961	0.847	0.945
Average weight gain (g/cattle/day)	689	593	522	760	163.0	605	772	439	748	230.0	0.686	0.320	0.762

Ma: Maize; **Ca:** cassava chips; **Es:** enegry sources; **TrO:** Tra fish oil, Es* TrO interaction; **BW:** body weight; **DMI:** dry matter intake; **OMI:** organic matter intake; **DDM:** digestive dry matter; **DOM:** digestive organic matter; CH_4, MJ/100 kg BW/day as methane emissions per 100 kg body weight daily.

calculated from the equation of Mills *et al.* (2003) with methane (MJ/day) = 1.06 + 10.27 Dietary forage proportion + 0.87 DMI. However, both DM intake and dietary forage proportions were similar in the experiment.

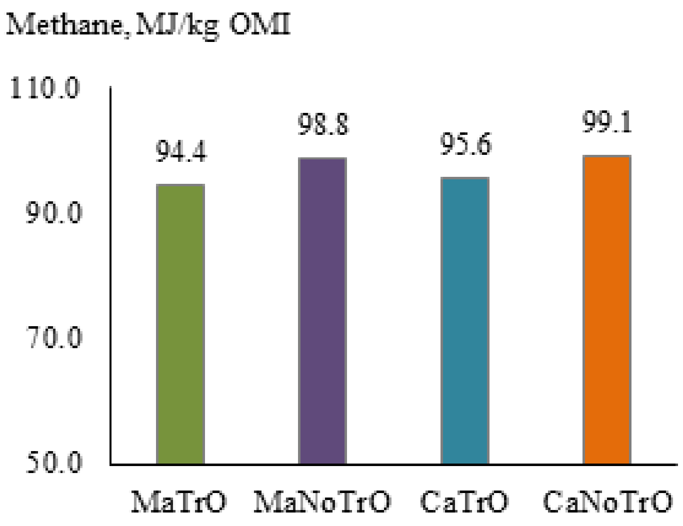

Figure 5: Methane emission in this study.

In this context of livestock-related emissions, Thu and Dong (2021) concluded that a consistent reduction of CH_4 production and no adverse effect on nutrient digestibility and rumen environment was found when increasing the catfish oil from 0 to 3% in the *in vitro* and *in vivo* experiments of the crossbred cattle. However, in term of quantitative comparison, cattle fed diets supplemented with fish oil had lower CH_4 emissions and daily weight gain than that of cattle fed diets without fish oil. This could because probably catfish oils inhibit the growth of certain methanogenic bacteria in the rumen, which are responsible for producing methane during digestion. These findings are compatible with the reports of previous authors (Ngu *et al.*, 2019; Quang *et al.*, 2020; Thu and Dong, 2021). Furthermore, According to Ho and Paul (2009) Tra catfish oil contained high polyunsaturated fatty acid. Ngu *et al.* (2019); Maia *et al.* (2007); Zhang *et al.* (2008) reported that fish oil or polyunsatureated fatty acid supplementation reduced *Fibrobacter succinogenes* population as well as acetic and propionic acid content, compared with the unsupplemented diet. The average weight gain on Charolais crossbred cattle was the lowest value for MaTrO and CaTrO treatments and the highest value for MaNoTrO and CaNoTrO treatments (605, 439, 772, and 748 g/cattle/day, respectively). The explanation of non-significant differences in weight gain in this study was the time because each experimental period was 21 days for nutrient digestibility.

Currently, Within the Tra fish oil diet groups, it was shown lower nutrient intake, digestibility and daily weight than without oil. More importantly, methane emission within the Tra fish oil group was less than without the oil group. According to Cho *et al.* (2024), increasing fat levels also affected the characteristics of rumen fluid, increasing the proportion of propionate in the rumen and reducing methane concentration in the exhaled gas in growth performance in growing Hanwoo steers. Another study, 90 days by Nhan *et al.* (2007) reported that cattle were affected by a sudden oil supply in the first period (0-30 days), and there was a tendency for lower feed intake with oil drench. The trend of DM intake was changed to an opposite direction, in which oil drench has slightly stimulated feed consumption (31-90 days of study).

CONCLUSIONS AND RECOMMENDATIONS

The maize tends to be better than cassava chips as an energy source for beef cattle fattening and reducing methane. Tra fish oil is rich in unsaturated fatty acids, which can suppress methane production in the rumen. Using the results of this study and continuing further research on beef cattle growth, a comprehensive review of Tra fish oil can be conducted to increase farmers' use of local by-product sources.

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NOVELITY STATEMENT

This study is the first to investigate the combination of energy feed and Tra fish oil on feed intake, nutrient digestibility, and nitrogen retention in Charolais crossbred cattle in the Mekong Delta of Vietnam. Our findings provide practical solutions for smallholder farmers to reduce methane.

AUTHOR'S CONTRIBUTIONS

Nguyen B. Truong: conceived, designed and performed the experiments and analyzed the data.
Nguyen B. Truong and Tran T. Tuan: wrote the paper.

All authors reviewed and approved the final manuscript.

Conflict of Interest

We certify that there is no conflict of interest.

REFERENCES

AbuGhazaleh AA, Schingoethe DJ, Hippen AR, Kalscheur KF, Whitlock LA (2002). Fatty acid profiles of milk and rumen digesta from cows fed fish oil, extruded soybeans or their blend. J. Dairy Sci., 85: 2266-2276. https://doi.org/10.3168/jds.S0022-0302(02)74306-3

Amorocho AK, Jenkins TC, Staples CR (2009). Evaluation of catfish oil as a feedstuff for lactating Holstein cows. J. Dairy Sci., 92(10): 5178-5188. https://doi.org/10.3168/jds.2009-2283

AOAC (Association of Official Analytical Chemists) (1990). Official methods of analysis (15th ed.). Washington, DC, 1: 69-90.

Beauchemin KA, Kreuzer M, O'Mara F, McAllister TA (2008). Nutritional management for enteric methane abatement: A review. Aust. J. Exp. Agric., 48: 21–27. https://doi.org/10.1071/EA07199

Beauchemin KA, McGinn SM, Petit HV (2007). Methane abatement strategies for cattle: Lipid supplementation of diets. Can. J. Anim. Sci., 87: 431-440. https://doi.org/10.4141/CJAS07011

Bruinenberg M H, Valk H, Korevaar H, Struik PC (2002). Factors affecting digestibility of temperate forages from semi-natural grasslands. Grass Forage Sci., 57 (3): 292 - 301. https://doi.org/10.1046/j.1365-2494.2002.00327.x

Cho H, Jeong S, Kang K, Lee M, Jeon S, Kang H, Kim H, Seo J, Oh J, Seo S (2024). Effects of Dietary Fat Level of Concentrate Mix on Growth Performance, Rumen Characteristics, Digestibility, Blood Metabolites, and Methane Emission in Growing Hanwoo Steers. Animals, 14: 1-12. https://doi.org/10.3390/ani14010139

Donovan DC, Schingoethe DJ, Baer RJ, Ryali J, Hippen AR, Franklin ST (2000). Influence of dietary fish oil on conjugated linoleic acid and other fatty acids in milk fat from lactating dairy cows. J. Dairy Sci., 83: 2620–2628. https://doi.org/10.3168/jds.S0022-0302(00)75155-1

Dung DV (2014). *In vitro* fermentation characteristics of rice bran, maize, and cassava powder incubated with rumen fluid. J. Agric. Rural Dev., 98(10): 1-9.

Haque N (2018). Dietary manipulation: a sustainable way to mitigate methane emissions from ruminants. J. Anim. Sci. Technol., 60: 15. https://doi.org/10.1186/s40781-018-0175-7

Ho BT, Paul DR (2009). Fatty acid profile of Tra Catfish (*Pangasius hypophthalmus*) compared to Atlantic Salmon (*Salmo solar*) and Asian Seabass (*Lates calcarifer*). Int. Food Res. J., 16: 501-506.

Huhtanen P, Ramin M, Cabezas-Garcia EH (2016). Effects of ruminal digesta retention time on methane emissions: a modelling approach. Anim. Prod. Sci., 56:501–506. https://doi.org/10.1071/AN15507

Kabsuk J, Nusri-un J, Binsulong B, Gunha T, Sommart K (2024). Effects of Substituting Cassava Pulp with Broken Rice and Cassava Chips in Crossbred Holstein Diets: Rumen Fermentation, Enteric Methane Emission, and Energy Utilization. Animals, 14: 2257. https://doi.org/10.3390/ani14152257

Kaewpila C, Sommart K, Mitsumori M (2018). Dietary fat sources affect feed intake, digestibility, rumen microbial populations, energy partition and methane emissions in different beef cattle genotypes. Animals, 12(12): 2529-2538. https://doi.org/10.1017/S1751731118000587

Keady TWJ, Mayne CS (1999). The effects of level of fish oil inclusion in the diet on rumen digestion and fermentation parameters in cattle offered grass silage based diets. Anim. Feed Sci. Technol., 81(1 and 2): 57-68. https://doi.org/10.1016/S0377-8401(99)00073-5

Lesschen JP, Berg VDM, Westhoek HJ, Witzke HP, Oenema O (2011). Greenhouse gas emission profiles of European Lives. Anim. Feed Sci. Technol., 166: 16–28. https://doi.org/10.1016/j.anifeedsci.2011.04.058

Liu Y, Tao M, Dandan C, Naifeng Z, Bingwen S, Kaidong D, Yan T, Qiyu D (2019). Effects of tea saponin supplementation on nutrient digestibility, methanogenesis, and ruminal mic

https://doi.org/10.3390/ani9010029 robial flora in dorper crossbred ewe. Animals, 9: 1-11.
Maia MR, Chaudhary LC, Figueres L, Wallace RJ (2007). Metabolism of polyunsaturated fatty acids and their toxicity to the microflora of the rumen. Antonie Leeuwenhoek, 91(4): 303-314. https://doi.org/10.1007/s10482-006-9118-2
McDonald P, Edwards RA, Greenhalgh JFD, Morgan CA, Sinclair LA, Wilkinson RG (2010). Animals Nutrition (7th ed.). Longman Sci. Tech., N.Y. USA.
Mills JAN, Kebreab E, Yates CM, Crompton LA, Cammell SB, Dhanoa MS, Agnew RE, France J (2003). Alternative approaches to predicting methane emissions from dairy cows. J. Anim. Sci., 81: 3141-3150. https://doi.org/10.2527/2003.81123141x
Minitab (2021). Minitab Reference Manual. Release 20.3 for Windows, Minitab Inc., USA.
Nghiep HX, Truong NB (2024). Effects of coconut meat waste replacing maize in the diet on feed intake and nutrient digestibility of fattening beef cattle. Adv. Anim. Vet. Sci., 12(5): 856-861. https://doi.org/10.17582/journal.aavs/2024/12.5.856.861
Ngu NT, Nhan NTH, Hon NV, Danh LT, Vien DM, Anh LH, Xuan NH (2019). Effects of concentrate levels and oil supplementation in diets on rumen characteristics and perpormance of cattle. J. Anim. Plant Sci., 29(5): 1247-1253.
Nhan NTH, Ngu NT, Son VV, Preston TR, Leng RA (2007). Effects of oil drench on growth rate of cattle fattened on grass, supplemented with molasses, rice bran or rice straw. Lives. Res. Rural Dev., 19(9): 113.
Pimpa O, Binsulong B, Pastsart U, Pimpa B, Liang JB (2021). Bypass fat enhances liveweight gain and meat quality but not profitability of smallholder cattle fattening systems based on oil palm frond. Anim. Prod. Sci., 62: 1371–1378. https://doi.org/10.1071/AN20202
Quang NH, Khoa MA, Thang CM (2020). Effects of supplementation of vegetable oil and tannin on methane gas emission in raising cattle J. Anim. Sci. Technol., 108 (2): 34-42.
Siegford JM, Powers W, Grimes-Casey HG (2008). Environmental aspects of ethical animal's production. Poult. Sci., 87: 380–386. https://doi.org/10.3382/ps.2007-00351
Thu NV, Dong NTK (2021). A study of *in vitro* and *in vivo* greenhouse gas emissions, digestion, rumen environment and nitrogen retention of growing crossbred cattle supplemented by Catfish oil. Lives. Res. Rural Dev., 33: 68.
Van SPJ, Robertson JB, Lewis BA (1991). Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci., 74: 3583-3598. https://doi.org/10.3168/jds.S0022-0302(91)78551-2
Vargas JE, Andrés S, Ferreras LL, Snelling TJ, Ruíz DRY, Estrada CG, López S (2020). Dietary supplemental plant oils reduce methanogenesis from anaerobic microbial fermentation in the rumen. Sci. Rep., 10(1613): 1-9. https://doi.org/10.1038/s41598-020-58401-z
Whitlock L, Schingoethe DJ, Hippen AR, Kalscheur KF, Baer RJ, Ramaswamy N, Kasperson KM (2002). Fish oil and extruded soybeans fed in combination increase CLA in milk of dairy cows more than when fed separately. J. Dairy Sci., 85: 234–243. https://doi.org/10.3168/jds.S0022-0302(02)74072-1
Zhang C, Guo Y, Yuan Z, Wu Y, Wang J, Liu J, Zhu W (2008). Effect of octadeca carbon fatty acids on microbial fermentation, methanogenesis and microbial flora *in vitro*. Anim. Feed Sci. Technol., 146(3-4): 259-269. https://doi.org/10.1016/j.anifeedsci.2008.01.005