Effects of dietary seaweed supplementation on milk productivity, milk quality and health of dairy cows

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ABSTRACT

The objective of this study was to evaluate effects of dietary supplementation of a seaweed-originated product (SOP) on milk productivity, milk quality and health of milking cows under Vietnam weather conditions at the dairy farm of One Member Dairy and Beef Joint Stock Company HCMC, Vietnam from October 2019 to February 2020. A total of 40 Holstein Friesian crossbred cows were randomly allotted into 2 treatments in a randomized complete block design. The 2 dietary treatments included (1) cows fed a basal ration without SOP supplementation (control) and (2) control plus 70 g SOP/cow per day (about 0.35% dry matter intake/day). Parity, days in milk, body weight, and milk yield of cows in both treatments were almost equal ($P > 0.05$). The results showed that the average milk yield of cows over the experimental period was not different between the two treatments ($P > 0.05$), but the lactation stability curve was better in SOP group. The SOP supplementation also did not improve milk quality indicators (fat, protein, solids not fat, lactose, somatic cell count) as compared with the control ($P > 0.05$). The blood ketone level of cows in the control group was higher than that of cows in the SOP group ($P < 0.05$), although there were no differences in the blood levels of AST, ALT, protein, glucose, cholesterol, cortisol ($P > 0.05$). The SOP supplementation did not affect BW, body condition score, and locomotion score as well as the prevalences of lameness and digestive diseases ($P > 0.05$). Briefly, these results suggest that the dietary SOP addition of 70 g/cow per day appears not to improve milk productivity, milk quality and health of milking cows.

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1. Introduction

In tropical developing countries, dairy production systems are affected by many factors (Chu et al., 2004; Nguyen et al., 2016) including genetics, nutrition, infectious, parasitic diseases, or heat stress caused by high temperature and humidity. The development of dairy production in Vietnam requires the enhancement of knowledge and skills of farmers (Nguyen, 2021) related the general husbandry such as genetics (Bang et al., 2021c), nutrition (Nguyen & Diep, 2020b; Bang et al., 2021a), and heat stress (Bang et al., 2021b) management. In addition to the primary step from breed selection for improvement of milk productivity and feed efficiency, nutritional factors also affect milk yield and compositions (Hristov et al., 2004; Lee et al., 2014; Olika, 2021), so nutrient balance plays an important role in dairy production.

In recent years, seaweed (known as marine algae or marine macroalgae) has been interested in applied scientific fields, especially in nutritional composition and its benefits in the health improvement of humans and animals (Brown et al., 2014; Shi et al., 2019; Shimazu et al., 2019). In fact, it is very rich in several polysaccharides and complex carbohydrates (Makkar et al., 2016); or in useful metabolites and necessary minerals, being considered as a natural source of additives in various animals (Morais et al., 2020). It was indicated that seaweed addition into daily diets for milking cows significantly improved milk production (Baek et al., 2004; Lee et al., 2005; Cruywagen et al., 2015). Franklin et al. (1999) also demonstrated that lactation cow diets supplemented 910 g/cow per day of marine algae increased concentration of beneficial fatty acids in milk fat. Besides, Cruywagen et al. (2015) indicated a marine algae product at 90 g/cow per day improved not only milk yield but also ruminal pH and feed efficiency. In addition, Baek et al. (2004) revealed that brown seaweed residues supplementation at 800 g/cow per day (4%) into dairy cow diets stabilized rumen pH, improved milk yield and linoleic acid content. In Vietnam, however, the practical benefits of seaweed in dairy production are still limited and this study is needed to clarify this point.

Therefore, the objective of this study was to determine the effects of dietary supplementation of a seaweed product on milk yield and quality, some blood parameters, body condition score, lameness and digestive diseases of lactation cows under Vietnam weather conditions.

2. Materials and methods

2.1. Location

The experiment was conducted at the dairy farm of One Member Dairy and Beef Joint Stock Company HCM City, Vietnam from 10/2019 to 02/2020.

2.2. Experimental design, animals, and housing

The study was arranged into a randomized complete block design (block: parity) with two treatments of rations, including (1) cows fed a basal ration without seaweed-originated product (SOP, Oceanfeed^{TM} bovine product) supplementation (control) and (2) control plus 70 g SOP/cow per day (about 0.35% dry matter intake/day, DMI/day). Cows were housed in the same cubicle shed containing rubber mats with continual access to water. The study was conducted on a total of 40 Holstein Friesian (HF) crossbred cows with at least 3/4 HF blood, with parities at 1st - 4th, divided into two treatments (20 cows/treatment), and lasted 90 days. Cows in two treatments prior to experimental period were almost equal at parity, days in milk (DIM), body weight and milk yield ($P > 0.05$; Table 1).

2.3. Daily ration of cows

All cows were fed twice a day (6:30 and 15:00, *ad libitum*) as Total Mixed Ration (TMR) method including Hamil grass (25 kg/cow per day), alfalfa hay (2 kg/cow per day), complete feed (7 kg/cow per day), molasses (0.5 kg/cow per day), and brewers's grains (7 kg/cow per day). The seaweed-originated product (SOP) was mixed with new rice bran and mixed well with TMR for the SOP group twice a day. TMR feed was available at all positions of the feeding trough for the same consumption per cow. All cows were adapted to the experimental condition for two weeks in advance. All cows were washed and cleaned two times a day.

2.4. Sample collection and measurements

Milk yield (kg/cow per day): All cows were milked by milking system into specialized container two times a day (5:30 and 16:00), using the recording machine in the milking system, and then merging two times into the average milk yield/cow per day.

Milk quality: About 100 mL of milk were taken in the morning milking time to determine concentrations of milk fat, protein, solids not fat (SNF), lactose, somatic cell count (SCC), stored in the $2 - 6°C$ condition and transported quickly to an analytical laboratory. Milk quality was analyzed by Ekomilk Total machine (BULTEH 2000, Bulgaria) for about 60 sec/sample for the testing result. The SCC was quickly analyzed by Soma Ekomilk Scan (BULTEH 2000, Bulgaria) for about 4 min/sample with a limitation between 90 and 1.500×10^3 cells/mL.

Blood biochemical parameters: Some blood biochemical parameters analyzed in this study included aspartate aminotransferase (AST), alanine aminotransferase (ALT), protein, glucose,

Table 1. Experimental design

Treatment	Control (No dietary SOP addition)	SOP (Dietary SOP addition)
Cows (n)	20	20
Parity ($P = 0.324$)	2.20 ± 1.15	2.15 ± 1.03
DIM (days) ($P = 0.840$)	119.42 ± 32.71	124.34 ± 27.42
Body weight (kg/cow) ($P = 0.487$)	487.21 ± 52.84	496.74 ± 48.76
Milk yield (kg/cow per day) ($P = 0.798$)	15.68 ± 4.75	15.33 ± 3.96
Daily dietary SOP addition (g/cow per day)	0	70

cholesterol, cortisol and ketone. The blood samples of 2 mL/cow were taken from separate individuals at the farm and added to the tube without anticoagulant, but contained micronized silica granules. To ensure the same condition for all samples, they were collected from 9:00 to 11:00. After collection, samples were stored at 2 - 8°C and transferred to Medlatec hospital and analyzed for blood biochemistry (AST, ALT, protein, glucose, and cholesterol) by Accelerator A3600 system with 60 min/sample and cortisol by Cobass 8100 system for 90 min/sample. Ketone level was measured by FreeStyle Optium Neo Ketone Monitoring System at farm by which a 6 μL of blood dropped to FreeStyle Optium blood β-Ketone test strips in 10 sec/sample.

Body weight (BW, kg/cow): Cows were weighed individually at the beginning and the end of the experimental period by a specialized electronic scale (Electronic scale, VNS China) in the morning before feeding.

Body condition score (BCS): Individual cow was evaluated for BCS ranging from 1 to 5 according to the official method described by Wildman et al. (1982) at the beginning and the end of the experimental period.

Locomotion score (LS): Based on locomotion scoring method determined by Sprecher et al. (1997) from 1 to 5 with non to severe lameness, respectively. The LS of all cows was recorded every week to have a total of 12 recording times of LS per cow during 90 days of experiment. Cows with score more than 3 were assigned into lameness group.

Digestive diseases (%): All cows were observed and recorded for all issues related to digestive diseases in the experimental period to calculate the percentage of digestive diseases per treatment. The signals of digestive diseases were recognized from feces with its height, color, consistency, bubbles, mucous and foamy (Hall, 2002; Heinrichs et al., 2016).

2.5. Statistical analysis

Data were analyzed as a randomized complete block design by ANOVA using the GLM procedure of Minitab Software version 16.2. The individual cow was considered an experimental unit for all parameters. The average values were compared by Tukey test and the percentages were compared by χ^2 test, the differences were considered significant at $P \leq 0.05$.

3. Results

3.1. Milk yield and lactation stability curve

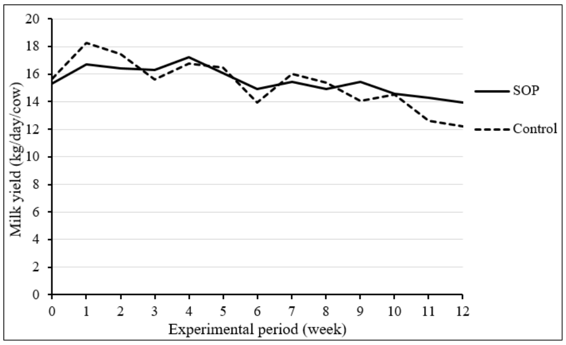

Figure 1. Effect of seaweed-originated product (SOP) addition on lactation stability curve during experiment.

The milk yield of cows in both groups had a downward trend in the mild lactation stage, but the lactation curve of cows fed the dietary SOP supplementation was more stable than that of cows fed control diet without SOP product with large oscillations (Figure 1). However, there was no significant difference in average milk yield between two treatments ($P = 0.740$; Table 2).

3.2. Milk quality

The percentages of milk quality indicators (fat, SNF, protein, lactose) of cows fed the farm-based ration were not different from those of cows fed diet supplemented SOP product ($P > 0.05$; Table 3). The level of somatic cell count (SCC) in milk from control group was 327.10×10^3 cells/mL and higher than that in milk of SOP group of 274.70×10^3 cells/mL ($P = 0.574$).

3.3. Blood biochemical parameters

The level of aspartate aminotransferase (AST), alanine aminotransferase (ALT), total protein, glucose, total cholesterol and cortisol in blood of cows fed the farm-based ration were not different from those of cows fed diet supplemented SOP product ($P > 0.05$; Table 4). However, the average blood ketone level of cows in control group was 0.81 mmol/L and significantly higher than that of cows in SOP group of 0.68 mmol/L a ($P = 0.017$).

3.4. Body weight, lameness and digestive diseases

The average body weight (BW), body condition score (BCS) and locomotion score (LS) of cows fed the current farm-based ration after 90 days of experiment were not different from those of cows fed the daily SOP supplementation diet ($P > 0.05$; Table 5). The total of 12 times of LS evaluations during the 90-day period per cow, there were 35 cases of lameness in control treatment which accounted for 14.58% and were not different from those of SOP treatment which had 27 cases of lameness which accounted for 11.25% ($P = 0.341$; Table 6). Besides, there were two cases of diarrheas with bubbles in feces and one case of light rumen acidosis in control group which accounted for 15.00% and were not different from those of SOP group which had one case of diarrhea with bubbles in feces which accounted for 5.00% ($P = 0.605$). There were not any signals of other diseases related to the gastrointestinal tract during the experimental period.

4. Discussion

The present study showed that although the dietary SOP addition helped the lactation curve more stable during 90 days of the experiment, it could not significantly improve ($P > 0.05$) the average milk yield as compared with control group without SOP addition. Although there was a tendency to improve milk quality in all five indicators (fat, SNF, protein, lactose and SCC) from the dietary SOP supplementation group, these tested parameters did not differ significantly between two treatments ($P > 0.05$). Therefore, the dietary supplementation with SOP at 70 g/cow per day (about 0.35% DMI/day) could not remarkably improve milk productivity and quality under Vietnam dairy husbandry conditions. In agreement with our study, Newton et al. (2021) showed that the diet with a small amount of seaweed supplementation (0-158 g/cow per day) for dairy cows was not adequate to improve considerably these parameters. It was also demonstrated that the dietary seaweed supplementation for dairy cows did not affect milk productivity and basic compositions (Lopez et al., 2016; Antaya et al., 2019; Hein, 2021). In addition, Karatzia et al. (2012) reported a lack of effect of

Table 2. Effect of dietary seaweed-originated product (SOP) supplementation on average milk yield

Treatment/Milk yield	n (cows)	$\overline{X}$ ± SD (kg/cow per day)	SEM	*P*
Control	20	16.08 ± 3.12	1.051	0.740
SOP	20	16.15 ± 2.56		

Table 3. Effect of dietary seaweed-originated product (SOP) supplementation on milk quality

Milk compositions	Control	SOP	SEM	*P*
n (cows)	20	20		
Fat (%)	3.50 ± 0.45	3.61 ± 0.44	0.122	0.478
Solids not fat (SNF) (%)	9.14 ± 0.25	9.17 ± 0.38	0.087	0.804
Protein (%)	3.57 ± 0.09	3.61 ± 0.14	0.029	0.265
Lactose (%)	4.89 ± 0.21	4.89 ± 0.21	0.058	0.967
SCC ($\times 10^3$ cells/mL)	327.10 ± 34.00	274.70 ± 24.80	77.82	0.574

SCC: somatic cell count.

Table 4. Effect of dietary seaweed-originated product (SOP) supplementation on some blood biochemical parameters

Blood biochemical parameters	Control	SOP	SEM	*P*
n (cows)	20	20		
AST (U/L)	74.69 ± 12.67	75.12 ± 9.12	2.367	0.915
ALT (U/L)	18.16 ± 6.94	18.39 ± 5.30	1.639	0.903
Protein (g/L)	75.68 ± 4.69	76.60 ± 5.17	1.208	0.526
Glucose (mmol/L)	2.04 ± 0.40	2.06 ± 0.38	0.106	0.898
Glucose (mg/dL)	43.05 ± 3.03	45.75 ± 5.93	1.273	0.083
Cholesterol total (mmol/L)	5.40 ± 1.19	5.79 ± 3.03	0.646	0.607
Cortisol (nmol/L)	27.24 ± 12.03	24.36 ± 8.41	1.130	0.199
Ketone (mmol/L)	0.81^{a} ± 0.19	0.68^{b} ± 0.18	0.044	0.017

[ab]Means in the same column without common letter are different at $P \leq 0.05$

Table 5. Effect of dietary seaweed-originated product (SOP) supplementation on body weight (BW), body condition score (BCS) and locomotion score (LS)

Parameters	Control	SOP	SEM	*P*
n (cows)	20	20		
BW day 1 (kg/cow)	482.97 ± 49.42	491.52 ± 43.96	14.186	0.548
BW day 90 (kg/cow)	475.90 ± 71.80	498.00 ± 65.00	16.821	0.276
BCS day 1	2.81 ± 0.51	3.08 ± 0.57	0.140	0.120
BCS day 90	3.09 ± 0.55	3.14 ± 0.67	0.173	0.198
LS day 1	2.45 ± 1.34	2.30 ± 1.28	0.242	0.720
LS day 90	2.24 ± 1.10	2.19 ± 1.07	0.220	0.850

Table 6. Effect of dietary seaweed-originated product (SOP) supplementation on prevalences of lameness and digestive diseases

Prevalence of lameness based on locomotion score (LS)				
Treatment	n (Evaluation times of LS)	Evaluation times with LS > 3	Percentage of disease case (%)	*P*
Control	240	35	14.58	0.341
SOP	240	27	11.25	
Digestive diseases				
Treatment	n (cows)	Cows with digestive disease	Percentage of disease case (%)	*P*
Control	20	3	15.00	0.605
SOP	20	1	5.00	

dietary seaweed supplementation at 80 g/cow per day on the average daily milk production, milk protein and fat. Moreover, Hong et al. (2015) reported that the addition of seaweed by-products (2 – 4% DM) in Holstein cattle diet during transition did not affect daily milk yield and compositions. In contrast, it was illustrated that milk yield and some milk basic constituents were remarkably improved by daily dietary seaweed addition at 90 g/cow per day (0.4% DM) (Cruywagen et al., 2015) or 910 g/cow per day (Franklin et al., 1999). In addition, Baek et al. (2004) and Lee et al. (2005) indicated that seaweed added 4% DMI/day (800 g/cow per day) into diets of dairy cows significantly increased milk yield, but not milk compositions. Interestingly, Newton et al. (2021) revealed that the low supplementation of seaweed (13-40 g/cow per day) did not increase milk yield and quality whereas the dietary high seaweed concentration (26-158 g/cow per day) improved considerably some milk quality parameters (milk protein and casein) without a difference in milk yield and other milk compositions (milk fat, lactose, free fatty acids, SCC). Therefore, there was a wide variation in the effectiveness of SOP supplementation on milk performance and quality in the various supplemented concentrations in recent studies (Baek et al., 2004; Lee et al., 2005; Newton et al., 2021) and only a noticeable enhancement with seaweed supplementation from 90 g/cow per day (equivalent to 0.4% DMI/day) (Cruywagen et al., 2015). As a result, no effect of dietary seaweed supplementation on dry matter intake and feed efficiency of dairy cows (Hong et al., 2015; Hein, 2021) from a relatively small consumption amount (Newton et al., 2021) could be the reason for no differences between two groups in this study.

Regarding results of blood biochemical parameters, there was a considerable improvement of average ketone level in specific ($P < 0.05$) and ketosis disease in general in cows fed daily diet supplemented SOP product at 70 g/cow per day compared with control group without SOP, although the other parameters (AST, ALT, protein, glucose, cholesterol, cortisol) were relatively similar between two treatments ($P > 0.05$). The SOP group showed better stability of blood ketone levels in the normal range (< 1.4 mmol/L) (Oetzel, 2004; Nguyen & Diep, 2020a) for dairy cows during the experiment and this could be the main reason for no case of ketosis disease in SOP group while the subclinical ketosis disease appeared in control group. Interestingly, there was a downward trend in blood cortisol from SOP group with an average reduction of 2.88 nmol/L in comparison with control group, in spite of no considerable difference. It was demonstrated that cortisol concentrations could be increased by effects of stressors such as pain, heat stress or high ambient temperature (Chaiyabutr et al., 2008; Aggarwal & Upadhyay, 2013). Therefore, it would be of interest in future studies to determine precisely whether dietary SOP supplementation with various concentrations could alleviate the stress status for dairy production under Vietnam weather conditions. Ibrahim et al. (2020) showed the effect of dietary seaweed addition in lamb diets in heat stress conditions was significantly different at a level of 2 or 4%; in particular, a significant increase in total protein at 4% but not at 2%, a considerable rise in blood glucose at 2% but not at 4%, and a remarkable decrease in total cholesterol at both levels, as compared with control. Besides, Karatzia et al. (2012) also revealed that seaweed supplementation at 80 g/cow per day for dairy cows markedly improved blood glucose, but not for the other parameters. In fact, the current results indicated that the blood glucose levels in both groups were slightly lower than the normal level of dairy cows ($\leq$ 2.22 mmol/L) (Dubuc & Buczinski, 2018). Hence, it manifested that the current farm ration could be unbalanced with key nutrients such as protein and energy, suggesting that the unbalanced diets might be one of the important factors affecting the SOP product efficacy, although studies with a larger number of samples will be needed to clarify this point.

The current study revealed that BW, BSC, and LS of lactation cows were not affected by SOP supplementation. This is totally consistent with the results of previous studies about no effect of seaweed supplementation on BW and BSC of dairy cows (Hong et al., 2015), possibly because of no effect of it on feed intake (Baek et al., 2004; Lee et al., 2005; Hein, 2021) and feed efficiency (Hong et al., 2015). However, Cruywagen et al. (2015) indicated that seaweed supplementation at 90 g/cow per day (0.4% DM) had a greater effect on the efficiency of feed conversion into milk. Besides, the figures in this study also exhibited that the cows were healthy with addition of dietary SOP product, leading to a decrease on the prevalences of lameness and digestive diseases with the positively improved trend, despite no statistically significant differences.

5. Conclusions

The dietary SOP addition of 70 g/cow per day was not sufficient to yield a significant improvement on important parameters in dairy production such as milk yield, basic compositions, BW, BSC, LS, some blood biochemical indicators, or reduced prevalences of lameness and digestive diseases; except for a remarkedly improvement in the lactation stability curve and blood ketone level. Therefore, further investigations are urgently required to accurately assess the effectiveness of dietary SOP supplementation under practical dairy husbandry conditions of Vietnam through an extensive study with different supplemental concentrations. Besides, it would also be interesting in future studies to examine whether the dietary nutrient balance affects the efficacy of SOP addition into dairy cattle diets.

Conflict of interest

The authors declare no conflict of interest.

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References

Aggarwal, A., & Upadhyay, R. (2013). *Heat stress and animal productivity.* Haryana, India: Springer. https://doi.org/10.1007/978-81-322-0879-2_2.

Antaya, N. T., Ghelichkhan, M., Pereira, A. B. D., Soder, K. J., & Brito, A. F. (2019). Production, milk iodine, and nutrient utilization in Jersey cows supplemented with the brown seaweed *Ascophyllum nodosum* (kelp meal) during the grazing season. *Journal of Dairy Science* 102(9), P8040-8058. https://doi.org/10.3168/jds.2019-16478.

Baek, I. K., Maeng, W. J., Lee, S. H., Lee, H. G. Lee, S. R., Ha, J. K., Lee, S. S., & Hwang, J. H. (2004). Effects of the brown seaweed residues supplementation on in vitro fermentation and milk production and composition of lactating dairy cows. *Journal of Animal Science and Technology* 46(3), 373-386. https://doi.org/10.5187/JAST.2004.46.3.373.

Bang, N. N., Chanh, N. V., Trach, N. X., Khang, D. N., Hayes, B. J., Gaughan, J. B., Lyons, R. E., Hai, N. T., & McNeill, D. M. (2021a). Issues of feeding strategy for lactating cows in Vietnamese smallholder dairy farms. *Animals* 11(3), 729. https://doi.org/10.3390/ani11030729.

Bang, N. N., Gaughan, J. B., Hayes, B. J., Lyons, R. E., Chanh, N. V., Trach, N. X., Khang, D. N., & McNeill, D. M. (2021b). Characteristics of cowsheds in vietnamese smallholder dairy farms and their associations with microclimate-a preliminary study. *Animals* 11(2), 351. https://doi.org/10.3390/ani11020351.

Bang, N. N., Hayes, B. J., Lyons, R. E., Randhawa, I. A. S., Gaughan, J. B., & McNeill, D. M. (2021c). Genomic diversity and breed composition of Vietnamese smallholder dairy cows. *Journal of Animal Breeding and Genetics* 139(2), 145-160. https://doi.org/10.1111/jbg.12651.

Brown, E. M., Allsopp, P. J., Magee, P. J., Gill, C. I. R., Nitecki, S., Strain, C. R., & McSorley, E. M. (2014). Seaweed and human health. *Nutrition Reviews* 72(3), 205-216. https://doi.org/10.1111/nure.12091.

Chaiyabutr, N., Chanpongsang, S., & Suadsong, S. (2008). Effects of evaporative cooling on the regulation of body water and milk production in crossbred Holstein cattle in a tropical environment. *International Journal of Biometeorology* 52(7), 575-585. https://doi.org/10.1007/s00484-008-0151-x.

Chu, L. T. K., Yokogawa, H., & Kawaguch, T. (2004). Dairy Production in Vietnam: Opportunities and Challenges. *Journal of the Faculty of Agriculture, Kyushu University* 49(1), 179-193. https://doi.org/10.5109/4578.

Cruywagen, C. W., Taylor, S., Beya, M. M., & Calitz, T. (2015). The effect of buffering dairy cow diets with limestone, calcareous marine algae, or sodium bicarbonate on ruminal pH profiles, production responses, and rumen fermentation. *Journal of Dairy Science* 98(8), 5506-5514. https://doi.org/10.3168/jds.2014-8875.

Dubuc, J., & Buczinski. S. (2018). Cow-and herd-level prevalence of hypoglycemia in hyperketonemic postpartum dairy cows. *Journal of Dairy Science* 101(4), 3374-3379. https://doi.org/10.3168/jds.2017-13773.

Franklin, S. T., Martin, K. R., Baer, R. J., Schingoethe, D. J., & Hippen, A. R. (1999). Dietary Marine Algae (Schizochytrium sp.) Increases concentrations of conjugated linoleic, docosahexaenoic and transvaccenic acids in milk of dairy cows. *The Journal of Nutrition* 129(11), 2048-2054. https://doi.org/10.1093/jn/129.11.2048.

Hall, M. B. (2002). Characteristics of manure: What do they mean? In Eastridge, M. L. (Ed.), *Proceedings of the Tri-State Dairy Nutrition Conference* (141-147). Indiana, USA. Retrieved July 8, 2020, from https://20fd2ea1-0814-41a9-868d-fa06f395c8c2.filesusr.com/ugd/36a444_e86c8527f0794013b88cea957e3890f9.pdf.

Hein, T. (2021). *Red seaweed as a feed additive to stop methane production*. Retrieved May 4, 2021, from https://www.allaboutfeed.net/all-about/new-proteins/red-seaweed-stops-methane-production/.

Heinrichs, J., Varga, G. A., & Kononoff, P. (2016). *Using manure evaluation to enhance dairy cattle nutrition*. Retrieved November 22, 2019, from https://extension.psu.edu/using-manure-evaluation-to-enhance-dairy-cattle-nutrition.

Hong, Z. S., Kim, E. J., Jin, Y. C., Lee, J. S., Choi, Y. J., & Lee, H. G. (2015). Effects of supplementing brown seaweed by-products in the diet of Holstein cows during transition on ruminal fermentation, growth performance and endocrine responses. *Asian-Australasian Journal of Animal Sciences* 28(9), 1296-1302. https://doi.org/10.5713/ajas.15.0235.

Hristov, A. N., Price, W. J., & Shafii, B. (2004). A meta-analysis examining the relationship among dietary factors, dry matter intake, and milk and milk protein yield in dairy cows. *Journal of Dairy Science* 87(7), 2184-2196. https://doi.org/10.3168/jds.S0022-0302(04)70039-9.

Ibrahim, N. H., Ellamie, A. M., Fouda, W. A., & Younis, F. E. (2020). Physiological and behavioral responses of growing barki ram lambs exposed to heat stress and fed brown seaweed as additives under semiarid conditions. *Journal of Animal and Poultry Production* 11(2), 55-65. https://doi.org/10.21608/jappmu.2020.84566.

Karatzia, M., Christaki, E., Bonos, E., Karatzias, C., & Florou-Paneri, P. (2012). The influence of dietary Ascophyllum nodosum on haematologic parameters of dairy cows. *Italian Journal of Animal Science* 11(2), 169-173. https://doi.org/10.4081/ijas.2012.e31.

Lee, H. G., Hong, Z. S., Li, Z. H., Xu, C. X., Jin, X., Jin, M. G., Lee, H. J., Choi, N. J., Koh, T. S., & Choi, Y. J. (2005). Effect of brown seaweed waste supplementation on lactational performance and endocrine physiology in Holstein lactating cows. *Journal of Animal Science and Technology* 47(4), 573-582. https://doi.org/10.5187/JAST.2005.47.4.573.

Lee, J., Seo, J., Lee, S. Y., Ki, K. S., & Seo, S. (2014). Meta-analysis of factors affecting milk component yields in dairy cattle. *Journal of Animal Science and Technology* 56(1), 5. https://doi.org/10.1186/2055-0391-56-5.

Lopez, C. C., Serio, A., Rossi, C., Mazzarrino, G., Marchetti, S., Castellani, F., Grotta, L., Fiorentino, F. P., Paparella, A., & Martino, G. (2016). Effect of diet supplementation with Ascophyllum nodosum on cow milk composition and microbiota. *Journal of Dairy Science* 99(8), 6285-6297. https://doi.org/10.3168/jds.2015-10837.

Makkar, H. P. S., Tran, G., Heuzé, V., Giger-Reverdin, S., Lessire, M., Lebas, F., & Ankers, P. (2016). Seaweeds for livestock diets: A review. *Animal Feed Science and Technology* 212, 1-17. https://doi.org/10.1016/j.anifeedsci.2015.09.018.

Morais, T., Inácio, A., Coutinho, T., Ministro, M., Cotas, J., Pereira, L., & Bahcevandziev, K. (2020). Seaweed potential in the animal feed: A review. *Journal of Marine Science and Engineering* 8(8), 559. https://doi.org/10.3390/jmse8080559.

Newton, E. E., Pétursdóttir, Á. H., Ríkharðsson, G., Beaumal, C., Desnica, N., Giannakopoulou, K., Juniper, D., Ray, P., & Stergiadis, S. (2021). Effect of dietary seaweed supplementation in cows on milk macrominerals, trace elements and heavy metal concentrations. *Foods* 10(7), 1526. https://doi.org/10.3390/foods10071526.

Nguyen, H. M., Jean-Daniel, C., Pham, K. D., Hoang, Q. V., & Guillaume, D. (2016). Which is a sustainable development of dairy sector in Vietnam: Dairy household farms or intensive and large scale farms. *Journal of Animal Science and Technology* 61, 12-21.

Nguyen, T. H., & Diep, T. T. (2020a). Efficacy of PCDairy application in optimal ration formulation for milking cows on milk productivity and quality. *Can Tho University Journal of Science* 12(1), 1-7. https://doi.org/10.22144/ctu.jen.2020.001.

Nguyen, H. T., & Diep, T. T. (2020b). Efficacy of propylene glycol on prevention and treatment of ketosis for dairy cows in lactation stage. *The Journal of Agriculture and Development* 19(2), 28-35. https://doi.org/10.52997/jad.4.02.2020.

Nguyen, N. B. (2021). *Strategies to improve dairy cow productivity and welfare in Vietnam* (Unpublished doctoral dissertation). The University of Queensland, Queensland, Australia.

Oetzel, G. R. (2004). Monitoring and testing dairy herds for metabolic disease. *Veterinary Clinics of North America: Food Animal Practice* 20(3), 651-674. https://doi.org/10.1016/j.cvfa.2004.06.006.

Olika, C. D. (2021). Review on effect of nutrition on milk composition and yield of dairy cows. *European Journal of Science, Innovation and Technology* 1(2), 24-31.

Shi, H., Kim, S. H., & Kim, I. H. (2019). Effect of dietary inclusion of fermented sea mustard by-product on growth performance, blood profiles, and meat quality in broilers. *Journal of the Science of Food and Agriculture* 99(9), 4304-4308. https://doi.org/10.1002/jsfa.9663.

Shimazu, T., Borjigin, L., Katoh, K., Roh, S., Kitazawa, H., Abe, K., Suda, Y., Saito, H., Kunii, H., Nihei, K., Uemoto, Y., Aso, H., & Suzuki, K. (2019). Addition of Wakame seaweed (Undaria pinnatifida) stalk to animal feed enhances immune response and improves intestinal microflora in pigs. *Animal Science Journal* 90(9), 1248-1260. https://doi.org/10.1111/asj.13274.

Sprecher, D. J., Hostetler, D. E., & Kaneene, J. B. (1997). A lameness scoring system that uses posture and gaitto predict dairy cattle reproductive performance. *Theriogenology* 47(6), 1179-1187. https://doi.org/10.1016/S0093-691X(97)00098-8.

Wildman, E. E., Jones, G. M., Wagner, P. E., Boman, R. L., Troutt, H. F., & Lesch, T. N. (1982). A dairy cow body condition scoring system and its relationship to selected production characteristics. *Journal of Dairy Science* 65(3), 495-501. https://doi.org/10.3168/jds.S0022-0302(82)82223-6.