The influence of dietary Ascophyllum nodosum on haematologic parameters of dairy cows

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Abstract

The aim of the study was to investigate the effect of Ascophyllum nodosum, an edible brown macroalga, on some haematologic parameters of dairy cows. Nineteen clinically healthy Holstein cows, an average 4.3 years old, were divided into two groups for 49 days. Ten cows received control diet (roughages and concentrate) while the concentrate of 9 cows was additionally supplemented with 80 g A. nodosum/cow/day. Average daily milk production (controls 39.6 kg/cow; A. nodosum 40.2 kg/cow), milk protein and fat were not affected by the alga supplementation. Glucose, sorbitol dehydrogenase, haemoglobin, haematocrit and white/red blood cells were evaluated in weekly intervals in both groups. The results showed that A. nodosum has the highest content of total polysaccharides among brown algae, ranging between 42-70% of dry weight (Holdt and Kraan, 2011). It is rich in unique polysaccharides (phycocolloids), such as alginic acid (28%), fucoidan (11.6%), laminarin (4.5%) and mannitol (7.5%) (O’Sullivan et al., 2010; Holdt and Kraan, 2011). These polysaccharides are not found in terrestrial plants (Khan et al., 2009) and most of them are dietary fibres which cannot be digested by the human organism. Therefore, they could potentially be used as prebiotic functional substances for human and animal health applications (Christaki et al., 2010; O’Sullivan et al., 2010; Holdt and Kraan, 2011).

The lipid content in A. nodosum is low, about 2-7% of dry weight, whereas there are sufficient amounts of n-3 fatty acids (Kumari et al., 2010) to offer protection from human cardiovascular diseases (Simopoulos, 2002). A. nodosum has a high concentration of vitamins (A, C, D, E) and minerals (Ca, P, Na and K) (Fitzgerald et al., 2011). Protein content varies between 3-15% (Fleurenone, 2004). In addition, it has been reported to contain acidic amino acids, ranging from 18% to 44% (Harnedy and Fitzgerald, 2011), and peptides that have been proven to have hypotensive effect on the human circulatory system (Fitzgerald et al., 2011). Other important components found in A. nodosum are polyphenols, such as phlorotannins, that can account for up to 15% of the algal dry mass and can act as antioxidants and antibacterial compounds (Wang et al., 2009; Holdt and Kraan, 2011). Furthermore, it contains carotenoids, especially the photosynthetic pigments like chlorophyll and fucoxanthine, which exhibit antioxidant capacity (Lordan et al., 2011).

Traditionally, A. nodosum has been used as soil fertilizer for many varieties of crops in coastal areas all over the world (Norrie and Hiltz, 1999). According to Simons-Boye et al. (2009), inclusion of up to 15% of A. nodosum in the diet produces no toxic effects, and in recent years A. nodosum has been utilized as an additive for animal feeding (Lordan et al., 2011). Meals or extracts of A. nodosum have been examined as natural feed supplements to improve animal health and performance in lambs (Saker et al., 2004; Archer et al., 2007), cattle (Anderson et al., 2006), weanling pigs (Dierick et al., 2009), grower-finisher pigs (Gardiner et al., 2008), and chickens (Gravett, 2000).

Nevertheless, there is no literature available on the influence of this seaweed on haematologic parameters of dairy cows. These parameters are recognized as a method of documenting overall animal health status (Kumar et al., 2003; Hagawane et al., 2009). Therefore, the aim of the present study was to determine whether the supplementation of the brown seaweed A. nodosum in the feed of dairy cows had any effect on their milk production and haematologic parameters.

Materials and methods

Animals

The study was carried out on a commercial farm in northern Greece. Nineteen healthy Holstein dairy cows, average age 4.3 years, which had previously completed at least one lactation period, were divided into two groups. The control group (A) had 10 cows and the A. nodosum group (B) had 9 cows. These animals had similar milk productivity (Group A 34.3 kg milk per cow/day; Group B 34.1 kg milk per cow/day) and there was no significant difference in their average body weight (Group A 523.1 kg; Group B 539.8 kg) (P>0.05). The whole experiment was performed under commercial conditions and lasted seven weeks. Animals were clinically examined every week.
Diets

The A. nodosum supplement used in this experiment was bought from Acadian Seaplants Limited, Dartmouth, Canada. According to the manufacturer, its chemical composition was: crude protein 6%, carbohydrates 52%, crude fibre 6%, crude fat 2%, ash 22%, moisture 12%, Ca 1%, P 0.1%, Na 2.4%, Cl 1%.

Cows in the control Group A received a diet without A. nodosum, whereas in Group B a total of 80 g powdered A. nodosum was added daily to the concentrate of each cow. The daily diet consisted of roughages (30 kg corn silage and 2 kg alfalfa, mixed with 2 kg molasses) served in the morning (8.00 am) and the evening (8.00 pm) and concentrate. The additional concentrate (Table 1) was offered individually to each cow twice a day, in the morning (7.00 am) and the evening (7.00 pm), in two equal meals after milking and with consideration given to individual cow milk production. The concentrate was formulated to meet the cows’ nutrient requirements in order to balance the milk production at a rate of 1 kg milk per day (mean±SD). All cows had free access to water.

The cows were acclimatized to their diet for a period of three weeks, beginning on Day 21 after calving, until Day 42. The first day of the experiment was Day 43 after calving.

Milk production

Milk production was recorded daily throughout the experiment. Milk protein and fat percentage were determined at weekly intervals using a MilkoScan 120 Analyzer (Foss Analytical, Slangerupgade, Denmark).

Results and discussion

There was no significant difference between the two groups in average milk production or milk protein and fat (P>0.05) during the whole experimental period (Table 2). Figure 1 shows the blood glucose concentration in the 7 weekly samplings. Glucose was significantly higher in the A. nodosum group compared to controls in the second (P<0.05), fourth (P<0.01), fifth (P<0.001), sixth (P<0.001) and seventh (P<0.001) weeks, although values remained within normal ranges. Also, SDH was significantly lower for the A. nodosum group compared to controls in the third (P<0.01), fourth (P<0.01), fifth (P<0.01), sixth (P<0.001) and seventh (P<0.001) weeks, although values remained within normal ranges (Figure 2).

Furthermore, there was no significant difference in haematologic parameters, Hb, PCV, and TLC, between the two groups in any of the weekly measurements and values stayed within normal ranges (P>0.05) (Table 3).

The present research indicates that the dietary addition of A. nodosum to dairy cows increased blood glucose levels compared to controls, and this effect was gradually more pronounced.

Haematologic parameters

At the end of every week, blood samples were collected from each cow immediately after the afternoon milking (7.00 pm), by jugular vein puncture, in Vacutette CE tubes (Greiner-Bio One) containing K3 EDTA. Haemoglobin (Hb, mg/dL), packed cell volume (PCV, %), erythrocyte count (TEC, ×10⁶/mm³) and total leukocyte count (TLC, ×10⁶/mm³) were determined in a Micros haematologic analyzer (OT-CT-OS-ABCvet-Ichor, ABX Diagnostics) according to the specific procedure of the manufacturer. Glucose was determined according to Barham and Trinder (1972) using a Gilford Stasar II photometer. Sorbitol dehydrogenase (SDH) was measured according to Gerlach and Hily (1974).

Statistical analysis

SPSS 16.0.1 statistical software (SPSS Inc., Chicago, IL, USA) was used to analyze experimental data. The general linear model function was used for the analysis of variance (ANOVA). A P level <0.05 was considered significant. Homogeneity of the variances was examined with Levene’s test (Levene, 1960).

Table 1. Composition of concentrate feed.

| Ingredients | % |
|-------------|---|
| Soybean meal | 30 |
| Maize | 20 |
| Carob pods | 18 |
| Wheat bran | 17 |
| Sunflower meal | 10.6 |
| Zeolite | 2 |
| Salt | 1 |
| Calcium phosphate | 0.4 |
| Calcium carbonate | 0.8 |
| Vitamin and trace mineral premix° | 0.2 |

°Supplying per kg concentrate feed: 13,000 U vitamin A, 2500 U vitamin D₃, 15 mg vitamin E, 1 mg vitamin B₁, 0.56 mg vitamin B₂, 0.5 mg vitamin B₆, 0.01 mg vitamin B₁₂, 12.5 mg vitamin niacin, 1.9 mg pantothenic acid, 0.15 mg folic acid, 100 mg Zn, 50 mg Fe, 100 mg Mg, 50 mg Mn, 6 mg Cu, 0.6 mg Co, 3 mg I, 0.5 mg Se.

Figure 1. Blood glucose concentration (mg/dL) of cows receiving either 0 g A. nodosum per cow every day or 80 g A. nodosum per cow per day (mean±SD). Groups differ significantly in weeks: 2nd (P<0.05), 4th (P<0.01), 5th (P<0.001), 6th (P<0.001) and 7th (P<0.001).

Figure 2. Blood sorbitol dehydrogenase concentrations (mU/mL) of cows receiving either 0 g A. nodosum per cow every day or 80 g A. nodosum per cow per day (mean±SD). Groups differ significantly in weeks: 3rd (P<0.01), 4th (P<0.01), 5th (P<0.01), 6th (P<0.001) and 7th (P<0.001).
pronounced over the duration of the experiment, although values remained within normal ranges (Braun et al., 2007). In previous studies, higher blood glucose levels have been reported when *A. nodosum* was added to the diets of goats (Kannan et al., 2007) or lambs (Archer et al., 2007).

The energy requirements of cows increase after calving and during lactation due to milk production and body maintenance (Reynolds, 2005). The blood glucose level is regarded as one of the indicators of energy status in ruminants and a precursor for lactose synthesis in the mammary gland (Schultz, 1968; Naficov and Beitz, 2007; Reynolds, 2005). It is known that cows that are high milk producers are only just able to synthesize sufficient glucose and are prone to metabolic disorders.

One possible mechanism by which *A. nodosum* may operate to increase the blood glucose of dairy cows is that this seaweed may increase the production of propionate in the rumen which finally leads to glucose production (Bergman et al., 1974). Propionate represents an important metabolic link between energy intake and liver glucose production, since up to 76% of liver glucose synthesis is produced from propionate (Reynolds et al., 1994). Gluconeogenesis is very important in ruminants and even more so in lactating cows (Naficov and Beitz, 2007).

Another possible mechanism could be that the addition of *A. nodosum* may stimulate the development of intestinal microflora resulting in improved feed digestion and better utilization of feed nutrients (Hnisova et al., 2011). Furthermore, it was reported that *A. nodosum* can limit the growth of potential pathogens, such as *E. coli* 0157:H7, both in *in vitro* (Wang et al., 2009) and *in vivo* studies on cattle (Braden et al., 2004). Furthermore, *A. nodosum* supplementation can enhance immune function and overall animal health in lambs (Saker et al., 2004), and beef steers (Saker et al., 2001; Anderson et al., 2006). This improved immunity seems to be related to the antioxidant content of the seaweed (Allen et al., 2001).

Another significant finding in our experiment is that dietary *A. nodosum* resulted in a gradual decrease in cow SDH during the lactation period under study, while SDH was gradually increased in the control cows; however, all values remained within reference ranges. SDH is a liver-specific enzyme in large domestic animals which is involved in carbohydrate metabolism. It catalyzes the conversion of fructose to sorbitol in hepatocytes (Soveri et al., 1992; Grucka-Mamczar et al., 2007). The activity of SDH in the blood of healthy animals is low, whereas its elevation above normal range indicates hepatocellular damage (Wiesner et al., 1965) and it is possible that the use of *A. nodosum* in this study could exert a hepatoprotective effect on the cows.

Good animal utilization of feed nutrients are of primary importance in efforts to increase milk protein and fat content (Neitz and Robertson, 1991). Consequently, it could be expected that *A. nodosum* supplementation in cow feed may result in increased milk production or changes in milk composition. Some researchers (McHugh 2003; Cvetkovic et al., 2004) who examined the use of *A. nodosum* meal in dairy cows found that milk production and milk protein content were increased. Nevertheless, in our study, there were no changes in milk production and milk protein and fat contents compared to control cows. Similar findings were also reported by Cermak et al. (2011) who examined hydrolyzed *A. nodosum* in dairy cows and Pompeu et al. (2011) who examined *A. nodosum* on heat stressed dairy cows. It can be hypothesized that the good animal health status and housing conditions in our experiment probably limited the beneficial effect of *A. nodosum* on milk production. In this experiment, blood Hb, PCV, TEC and TLC of dairy cows were measured in an effort to estimate overall health status. Red blood cells are sensitive to oxidative damage and this makes them an appropriate model for studying oxidative stress (Saker et al., 2004). Also, blood hemocrit and hemoglobin values give information about disorders such as anemia, lack of aminoacids, etc. (Ndioua et al., 2007) while white blood cells are linked to the immune system function (Archer et al., 2007). Since there were no significant differences between controls and cows fed *A. nodosum*, it can be deduced that erythropoiesis was not impaired by the seaweed under study and immune function was not affected.

**Table 2.** Milk production, milk protein and milk fat of cows receiving either 0 g *A. nodosum* per cow per day (Group A) or 80 g *A. nodosum* per cow per day (Group B).

| Weeks | Milk production, L/day | Milk protein, % | Milk fat, % |
|-------|------------------------|-----------------|------------|
|       | A          | B          | A          | B          |
| 1     | 39.5±5.9  | 39.4±5.9  | 3.2±0.2   | 3.2±0.2   | 3.8±0.1   | 3.8±0.2   |
| 2     | 40.0±5.8  | 39.8±5.2  | 3.2±0.2   | 3.2±0.2   | 3.8±0.1   | 3.8±0.2   |
| 3     | 40.1±5.1  | 40.1±6.2  | 3.3±0.2   | 3.3±0.2   | 3.9±0.1   | 3.8±0.2   |
| 4     | 39.9±5.3  | 40.4±5.8  | 3.2±0.2   | 3.2±0.2   | 3.8±0.1   | 3.9±0.2   |
| 5     | 40.1±5.7  | 40.6±5.4  | 3.2±0.2   | 3.2±0.2   | 3.8±0.1   | 3.8±0.2   |
| 6     | 39.1±5.8  | 40.4±5.3  | 3.2±0.2   | 3.2±0.2   | 3.8±0.1   | 3.9±0.2   |
| 7     | 38.9±5.4  | 40.8±5.3  | 3.2±0.2   | 3.3±0.2   | 3.9±0.1   | 3.9±0.2   |
| Average | 38.6±5.6 | 40.2±5.9 | 3.2±0.2   | 3.2±0.2   | 3.8±0.1   | 3.8±0.2   |

Values are presented as mean±SD. No significant differences were found between the two groups (P>0.05).

**Table 3.** Blood Hb, PCV, TEC and TLC of cows receiving either 0 g *A. nodosum* per cow per day (Group A) or 80 g *A. nodosum* per cow per day (Group B).

| Weeks | Hb, mg/dL | PCV, % | TEC, 10^6/mm³ | TLC, 10^3/mm³ |
|-------|-----------|-------|---------------|--------------|
|       | A        | B    | A             | B            | A            | B            |
| 1     | 8.9±0.6  | 8.7±0.4 | 26.2±1.16  | 25.1±1.1   | 5.6±0.8     | 5.5±0.6     | 7.1±1.1     | 7.5±0.9     |
| 2     | 9.0±0.7  | 8.6±0.3 | 26.0±1.9   | 25.2±1.2   | 5.6±0.7     | 5.5±0.6     | 7.1±1.0     | 7.5±0.9     |
| 3     | 8.9±0.6  | 8.6±0.5 | 24.9±1.7   | 24.9±1.2   | 5.3±0.7     | 5.5±0.6     | 7.2±1.0     | 7.5±0.8     |
| 4     | 9.0±0.8  | 8.7±0.5 | 26.1±2.1   | 25.4±1.3   | 5.6±0.7     | 5.6±0.7     | 7.1±1.1     | 7.4±0.7     |
| 5     | 9.1±0.8  | 8.5±0.5 | 26.0±1.4   | 25.6±1.2   | 5.8±0.7     | 5.7±0.7     | 6.7±1.1     | 7.4±0.7     |
| 6     | 8.8±0.7  | 8.7±0.5 | 27.0±1.4   | 25.4±1.5   | 5.5±0.7     | 5.7±0.5     | 6.6±0.9     | 7.1±1.3     |
| 7     | 8.8±0.5  | 8.7±0.8 | 24.4±1.1   | 25.6±1.2   | 5.7±0.6     | 5.7±0.7     | 6.5±1.3     | 7.2±1.5     |

Hb, haemoglobin, PCV, packed cell volume, TEC, erythrocyte count, TLC, total leucocyte count; values are presented as mean±SD; no significant differences were found between the two groups (P>0.05).
Conclusions

In conclusion, A. nodosum supplementation in dairy cow diet increased blood glucose levels, whereas it decreased blood SDH. Furthermore, it had no adverse effect on the examined haematologic parameters: Hb, PCV, TLC. Consequently, A. nodosum may be suggested as a functional ingredient in dairy cow nutrition, improving energy utilization and expressing a hepatoprotective effect.

References

Allen, V.G., Pond, K.R., Saker, K.E., Fontenot, J.P., Bagley, C.P., Ivy, R.L., Evans, R.R., Schmidt, R.E., Fike, J.H., Zhang, X., Ayad, J.Y., Brown, C.P., Miller, M.F., Montgomery, J.L., Mahan, J., Wester, D.B., Melton, C. 2001. Tasco: Influence of a brown seaweed on antioxidant in forages and livestoc-A review. J. Anim. Sci. 79:E21-E31.

Anderson, M.J., Blanton, J.R. Jr., Gleghorn, J., Kim, S.W., Johnson, J.W. 2006. Ascophyllum nodosum supplementation strategies that improve overall carcass merit of implanted English crossbred cattle. Asian-Aust. J. Anim. Sci. 19:1514-1518.

Archer, G.S., Friend, T.H., Caldwell, D., Ameiss, K., Krawczel, P.D. 2007. Effect of seaweed Ascophyllum nodosum on lambs during forced walking and transport. J. Anim. Sci. 85:225-232.

Barham, D., Trinder, P., 1972. Improved colour reagent for determination of blood glucose by oxidase system. Analyst 97:142-145.

Bergman, E.N., Brockman, R.P., Kaufman, C.F., Anderson, M.J., Blanton, J.R. Jr., Gleghorn, J., Ivy, R.L., Evans, R.R., Schmidt, R.E., Fike, J.H., Zhang, X., Ayad, J.Y., Brown, C.P., Miller, M.F., Montgomery, J.L., Mahan, J., Wester, D.B., Melton, C. 2001. Tasco: Influence of a brown seaweed on antioxidants in forages and livestock: A review. J. Anim. Sci. 79:E21-E31.

Dierick, N., Ovn, A., De Smet, S., 2009. Effect of feeding intact brown seaweed Ascophyllum nodosum on some digestive parameters and on iodine content in edible tissues in pigs. J. Sci. Food Agric. 89:584-594.

Fitzgerald, C., Gallagher, E., Tasadmir, D., Hayes, M., 2011. Heart health peptides from macroalgae and their potential use in functional foods. J. Agric. Food Chem. 59:6829-6836.

Flourence, J., 2004. Seaweed proteins. In: R.Y. Yada (ed.) Proteins in Food Processing. Woodhead Publishing Limited, Cambridge, UK, pp 197-213.

Gardiner, G., Campbell, A., O’Doerty, J., Pierce, E., Lynch, P., Leonard, F., Stanton, C., Ross, R., Lawlor, P., 2008. Effect of Ascophyllum nodosum extract on growth performance, nutrient digestibility, carcass characteristics and selected intestinal microflora populations of grower-finisher pigs. Anim. Feed Sci. Tech. 141:259-273.

Gerlach, U., Hiby, W., 1974. Sorbitol dehydrogenase. In: H.U. Bergmeyer (ed.) Methods of Enzymatic Analysis. Vol. 2, New York, Academic Press, pp 512-523.

Gravett, R.B., 2000. The effects of Ascophyllum nodosum on immune function, performance, and carcass characteristics of sheep and cattle. Degree Diss., Texas Tech University, Lubbock, TX, USA.

Hajiw, S., Hnisova, J., Petraskova, E., Cermak, B., Soch, M., Vostoupal, B., 2011. Influence of chosen stimulants on selected quality ingredients of cow’s milk and rumen parameters. Anim. Sci. Biotechnol. 44:19-23.

Harnedy, P.A., Fitzgerald, R.J., 2011. Bioactive proteins, peptides, and amino acids from macroalgae. J. Physiol. 47:218-232.

Hnisova, J., Petraskova, E., Cermak, B., Soch, M., Frelich, J., 2011. The effect of biostimulating substances on daily milk yield and quality components in cow’s milk. Anim. Sci. Biotechnol. 44:55-58.

Holdt, S.L., Kraan, S., 2011. Bioactive compounds in seaweed: functional food applications and legislation. J. Appl. Phycol. 23:371-393.

Kannan, G., Terrill, T. H., Kouakou, B., Galipalli, S., 2007. Blood metabolite changes and live weight loss following brown seaweed extract supplementation in goats subjected to stress. Small Ruminant Res. 73:228-234.

Khan, W., Rayirath, U.P., Subramanian, S., Jithesh, M., Rayorath, P., Hodges, D.M., Critchley, T.A., Craigie, J.S., Norrie, J., Prithiviraj, B., 2009. Seaweed extracts as biostimulants of plant growth and development. J. Plant Growth Regul. 28:386-399.

Kumar, B.R., Muralidharan, M.R., Ramesh, V., Arunachalam, S., Sivakumar, T., 2003. Effect of transport stress on blood profile in sheep. Indian Vet. J. 80:511-514.

Kumari, P., Kumar, M., Gupta, V., Reddy, C.R.K., Jha, B., 2010. Tropical marine macroalgae as potential sources of nutritionally important PUFAs. Food Chem. 120:740-757.

Levene, H., 1960. Robust tests for equality of variances. In: I. Olkin, S.G. Ghurye, W.G. Hoefding, W.G. Madow and H.B. Mann (eds.) Contributions to probability and statistics: essays in honor of Harold Hotelling. Stanford University Press, Palo Alto, CA, USA, pp 278-292.

Lordan, S., Ross, P.R., Stanton, C., 2011. Marine bioactives as functional food ingredients: potential to reduce the incidence of chronic diseases. Mar. Drugs 9:1056-1100.

McHugh, D.J., 2003. A guide to the seaweed industry. FAO fisheries technical paper 441. FAO Publ., Roma, Italy.

Nafikov, R.A., Beitz, D.C., 2007. Carbohydrate and lipid metabolism in farm animals. Symposium: History of Nutrition: impact of Research with Cattle, Pigs, and Sheep on Nutritional Concepts. J. Nutr. 137:702-705.

Ndlovu, T., Chimonyo, M., Okoh, A.I., Muchenje, V., Dzama, K., Raats, J.G., 2007. Assessing the nutritional status of beef cattle: Current practices and future prospects. Afr. J. Biotechnol. 6:2727-2734.

Neltz, M.H., Robertson, N.H., 1991. Composition of milk and factors that influence it.
Bulletin No. 421, Directorate of Agricultural Information, Department of Agriculture Publ., Pretoria, South Africa.
Norrie, J., Hiltz, D.A., 1999. Seaweed Extract Research and Applications in Agriculture. Agro Food Ind. Hi-Tech. 10:15-18.
O’Sullivan, L., Murphy, B., McLoughlin, P., Duggan, P., Lawlor, P.G., Hughes, H., Gardiner G.E., 2010. Prebiotics from marine macroalgae for human and animal health applications. Mar. Drugs 8:2038-2064.
Plaza, M., Cifuentes, A., Ibanez, E., 2008. In the search of new functional food ingredients from algae. Trends Food Sci. Tech. 19:31-39.
Pompeu, L.B., Williams, J.E., Spiers, D.E., Weaber, R.L., Ellersieck, M.R., Sargent, K.M., Feyerabend, N.P., Vellios, H.L., Evans, F., 2011. Effect of Ascophyllum nodosum on alleviation of heat stress in dairy cows. Professional Animal Scientist 27:181-189.
Reynolds, C.K., 2005. Glucose Balance in Cattle. pp 143-154 in Proc. Florida Ruminant Nutrition Conf., Gainesville, FL, USA.
Reynolds, C.K., Harmon, D.L., Cevara, M.J., 1994. Absorption and delivery of nutrients for milk protein synthesis by portal-drained viscera. J. Dairy Sci. 77:2787-2808.
Saker, K.E., Allen, V.G., Fontenot, J.P., Bagley, C.P., Ivy, R.L., Evans, R.R., Wester, D.B., 2001. Tasco-Forage: II. Monocyte immune cell response and performance of beef steers grazing tall fescue treated with a seaweed extract. J. Anim. Sci. 79:1022-1031.
Saker, K.E., Fike, J.H., Veit, H., Ward, D.L., 2004. Brown seaweed- (TascoTM) treated conserved forage enhances antioxidant status and immune function in heat-stressed wether lambs. J. Anim. Physiol. An. N. 88:122-130.
Schultz, L.H., 1968. Ketosis in dairy cow. J. Dairy Sci. 51:1133-1140.
Simopoulos, A.P., 2002. The importance of the ratio of omega-6/omega-3 essential fatty acids. Biomed. Pharmacother. 56:365-379.
Sovery, T., Sankari, S., Nieminen, M., 1992. Blood chemistry of reindeer calves (Rangifer tarandus) during the winter season. Comp. Biochem. Physiol. 102A:191-196.
Tierney, M., Croft, A.K., Hayes, M., 2010. A review of antihypertensive and antioxidant activity found in macroalgae. Bot. Mar. 53:387-408.
Wang, Y., Xu, Z., Bach, S.J., McAllister, T.A., 2009. Sensitivity of Escherichia coli to seaweed (Ascophyllum nodosum) phlorotannins and terrestrial tannins. Asian-Aust. J. Anim. Sci. 22:238-245.
Wiesner, I.S., Rawnsley, H.M., Brooks, F.P., Senior, J.R., 1965. Sorbitol dehydrogenase in the diagnosis of liver disease. Am. J. Dig. Dis. 10:147-151.