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Laxative effects of sea tangle (*Laminaria japonica*) snack in rats with low-fiber diet-induced constipation.

Ki-Woong Kim[1], Choel-Woo Kim[2], Dong-Soo Kang[1], and Sun Hee Cheong[1,*].

[1]Department of Marine Bio Food Science, College of Fisheries and Ocean Science, Chonnam National University, Yeosu 550-749, Republic of Korea
[2]Research Institute of Hyang-A Food Co., Ltd, Republic of Korea

ABSTRACT

Constipation is the most common gastrointestinal complaint all over the world and it is a risk factor of colorectal cancer. In the present study, we investigated the laxative effects of sea tangle (*Laminaria japonica*) snack in a rat model of low-fiber diet-induced constipation. The constipated rats were supplemented with 257.5 and 515 mg/kg body weight/day of the *Plantago asiatica* powder as a positive laxative agent and 500 and 1,000 mg/kg body weight/day of the sea tangle snack for 2 weeks during which the feeding characteristics, body weight, and fecal properties were monitored. The sea tangle snack increased fecal pellet number and wet weight of fecal pellets in the constipated rats, which are indications of laxative property of the sea tangle snack with the 1,000 mg/kg body weight showing the best efficacy. Moreover, fecal water content did tent to increase in the constipated rats supplemented with *Plantago asiatica* powder, a standard laxative agent, and sea tangle snack in a dose dependent manner after inducing constipation. Our results indicate that sea tangle snack has a laxative effect in a rat model of low fiber diet-induced constipation. In addition, these findings suggest that sea tangle snack may be effective on constipation as a complementary functional foods in humans suffering from life style-induced constipation.

Keywords: Constipation, Laxative effects, Low-fiber diet, Sea tangle (*Laminaria japonica*) snack

Corresponding author

INTRODUCTION

Constipation is a well-recognized public health problem to cause discomfort and to affect quality of life. Constipation is a highly prevalent gastrointestinal disorder affecting 3-15% of the general population and it can also cause abdominal distension, vomiting, restlessness, gut obstruction, and perforation [1]. The use of drugs that contain magnesium oxide or sennoside, the main constituent of Senna, correctol, senokot and gaviscon are commonly administered for the treatment of constipation due to their powerful laxative effects, but these chemical drugs are very limited due to their high cost and side-effect such as severe diarrhea [2]. Thus, the development of functional foods derived from natural sources are urgently needed to mitigate constipation with no adverse effects.

Sea tangle (Laminaria japonica) is the most common edible brown seaweed that is a popular dietary supplement and traditional marine foodstuff in Korea [3]. Sea tangle contains large amounts of protein, amino acids, minerals, and polyphenols. In addition, it consists of polysaccharides with alginates, fucoidan, fucoxanthin, laminarian, and insoluble cellulose, which is rich in dietary fiber, that act as anti-oxidant, antibacterial, anti-mutagenic, anti-inflammatory, anti-coagulation, anti-proliferation, and anti-biotic agents [4-7]. It has been revealed that sea tangle plays an important role for chronic idiopathetic constipation and improving blood glucose, serum lipids and antioxidant activity [8, 9]. However, no studies have reported on the dietary role of sea tangle snack as a functional food to improve the constipation induced by low-fiber diet in animal model.

Constipation arises from a variety of causes including dietary habits, psychological stress, and chemical compounds such as morphine and loperamide. In general, the animal model of loperamide-induced constipation corresponds to morphine-induced constipation in human because both loperamide and morphine are opioid-receptor agonists [10]. Therefore, we used a rat model of low-fiber diet-induced constipation, which has the similarities as human patients due to inadequate dietary habits. In the present study, we investigated the laxative effects of “Kelp Chip”, commercial sea tangle snack, using an animal model of low-fiber diet-induced constipation.

MATERIALS AND METHODS

Materials

The commercial Sea tangle (Laminaria japonica) snack, namely “Kelp Chip” was supplied by Hyanga Co., Ltd. (Wando, Korea). The Plantago asiatica powder, as a positive laxative agent, was supplied by Saerom Co., Ltd. (Jangheung, Korea).

Animals

Sixty male Sprague Dawley rats (5 weeks old) were purchased from SamTacho (Osan, Korea). The animals were housed at an animal room with controlled temperature (23 ± 2 °C) and humidity level (55 ± 10 %) under a 12-h light/dark cycle. All rats were provided with standard irradiated chow diet (Purina Mills, Seoungnam, Korea) and tap water were provided ad libitum. All animals were treated in accordance with the Guidelines for Care and Use of Laboratory Animals of Chonnam National University, Yeosu, Republic of Korea.

Induction and evaluation of constipation

After one week of acclimation to pelleted commercial diet, the rats were randomly divided into six treatment groups. One group (n = 10, Normal control) was fed a pelleted commercial diet and control group (n = 10) was fed a low-fiber diet (Central Lab. Animal Inc., Korea) for 8 weeks, respectively. Four groups (n =10, respectively) were fed a low-fiber diet for 8 weeks to induce constipation then were fed a Plantago asiatica powder (PAP257.5; 257.5 and PAP515; 515 mg/kg) as a standard laxative agent and sea tangle snack (STS500; 500 and STS1000; 1,000 mg/kg) for 2 weeks. The low-fiber diet (Central Lab. Animal Inc., Korea) contained 41.5% cornstarch, 24.5% milk casein, 10.0% sucrose, 10.0% dextrin, 7.0% mineral mixture, 6.0% corn oil, and 1.0% vitamin mixture (Table 1).

Table 1: Composition of the normal diet and low-fiber diet

	Contents (%)	
Ingredients	Normal diet	Low-fiber diet
Moisture	10.0	9.0
Crude protein	24.5	21.9
Crude fat	12.4	6.1
Crude fiber	3.7	0.1
Crude ash	7.25	5.9
Nitrogen Free Extract	63.1	57.0

Body weight, food intake, and food efficiency ratio

Body weight was measured once per 4 weeks during the experiment prior to inducing constipation (0-8 weeks). After inducing constipation (8-10 weeks), we measured food and water intake every day during the experiment. Food efficiency (%) was calculated by dividing the dietary intake amount during the same period of weight gain during the treatment period.

Number of fecal pellets, weight of fecal pellets, and fecal water content

Number of fecal pellets and wet weight of fecal pellets were measured once per 4 weeks during the experiment prior to inducing constipation (0-8 weeks). After inducing constipation (8-10 weeks), we collected and measured the number of fecal pellets and wet weight of fecal pallets every day during the experiment. The fecal water content was determined by drying the fecal pellets at 70°C for 24 hours in an oven and calculating the difference between the weight before drying and the weight after drying.

Statistical analysis

All data are expressed as means ± SEM. The data were evaluated by one-way analysis of variance. Differences between mean values were assessed using the Tukey-Kramer multiple comparison test. Differences were considered statistically significant when the P value was less than 0.05.

RESULTS AND DISCUSSION

Body weight, food intake, and food efficiency

There was no significant difference in body weight among the experimental groups during the experiment prior to inducing constipation (0-8 weeks). After inducing constipation (8-10 weeks), however, the body weight did tent to decrease in the normal control group compared to those of the other groups (Table 2). In contrast, You et al. [11] reported that consumption of sea tangle powder reduced average body weight in human. On the other hand, it has been reported that food intake is an important factor in evaluating constipation symptoms and therapeutic effects [12]. In addition, the reduction in the water consumed by the constipated animals may also be due to the effect of the chemical drug such as loperamide which probably accounted for the reduction in water content of the fecal pellets [13]. In the present study, however, there were no significant differences in the food and water intake of all the animals during the experiment period (Table 3). In a previous study, it was also reported that the apple fiber supplementation did not affected in the body weight and food intake in rats of morphine-induced constipation [14]. In the present study, the food efficiency (%) among the experimental groups during the experiment prior to inducing constipation (0-8 weeks) was not significantly different (Figure 1). However, the food efficiency (%) of the control, PAP and STS supplemented groups were significantly increased after inducing constipation compared to that of the normal control group.

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Table 2: Body weight change following treatment with sea tangle snack in rats with low-fiber diet-induced constipation

	Initial body weight (g)	4 week (g)	8 week (g)	10 week (g)
Normal	160.17 ± 5.43^{NS}	334.14 ± 21.46^{NS}	398.06 ± 30.19^{NS}	430.23 ± 46.09^{NS}
Control	159.82 ± 6.11	339.34 ± 21.93	396.39 ± 23.86	452.60 ± 38.71
PAP257.5	159.95 ± 6.01	338.21 ± 10.95	401.25 ± 11.72	477.33 ± 24.82
PAP515	159.99 ± 5.92	350.04 ± 20.16	415.64 ± 22.80	483.13 ± 27.55
STS500	160.04 ± 5.74	341.52 ± 12.14	402.10 ± 13.47	462.37 ± 18.76
STS1000	160.15 ± 5.54	342.03 ± 24.84	403.03 ± 28.42	473.86 ± 40.11

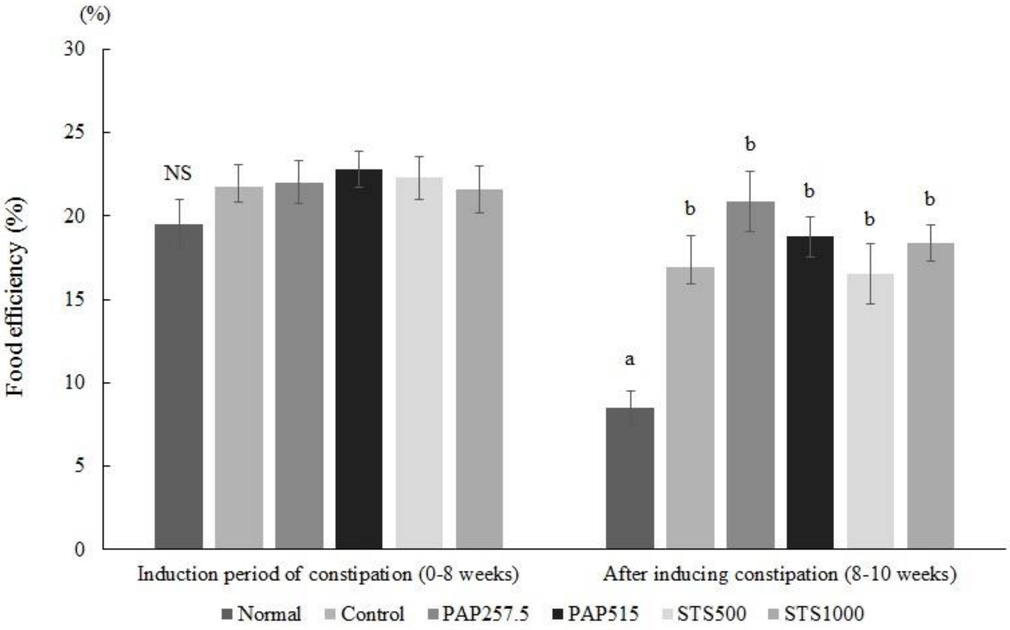
Values are means ± SEM (n = 10). NS: not significantly different among groups. Normal: normal control group; Control: low-fiber diet group; PAP257.5: Plantago asiatica powder (257.5 mg/kg)-treated group with low-fiber diet; PAP515: Plantago asiatica powder (515 mg/kg)-treated group with low-fiber diet (Central Lab. Animal Inc., Korea); STS500: sea tangle snack (500 mg/kg)-treated group with low-fiber diet; STS1000: sea tangle snack (1,000 mg/kg)-treated group with low-fiber diet.

Table 3: Food and water intake following treatment with sea tangle snack in rats with low-fiber diet-induced constipation

	Food intake (g/day)		Water consumption (g/day)
	Induction period of constipation (0-8 weeks)	After inducing constipation (8-10 weeks)	
Normal	22.86 ± 3.18^{NS}	22.15 ± 2.19^{NS}	43.13 ± 5.17^{NS}
Control	19.64 ± 3.19	23.07 ± 4.78	41.50 ± 9.07
PAP257.5	19.72 ± 3.21	22.50 ± 4.26	38.72 ± 10.79
PAP515	20.62 ± 3.59	21.53 ± 4.68	34.75 ± 10.78
STS500	19.73 ± 2.91	22.10 ± 3.87	35.75 ± 7.30
STS1000	20.18 ± 3.25	24.62 ± 3.29	38.93 ± 11.45

Values are means ± SEM (n = 10). NS: not significantly different among groups. Normal: normal control group; Control: low-fiber diet group; PAP257.5: Plantago asiatica powder (257.5 mg/kg)-treated group with low-fiber diet; PAP515: Plantago asiatica powder (515 mg/kg)-treated group with low-fiber diet (Central Lab. Animal Inc., Korea); STS500: sea tangle snack (500 mg/kg)-treated group with low-fiber diet; STS1000: sea tangle snack (1,000 mg/kg)-treated group with low-fiber diet.

Figure 1: Food efficiency (%) following treatment with sea tangle snack in rats with low-fiber diet-induced constipation. Values are means ± SEM (n = 10). Values not sharing a common letter are significantly different at $P < 0.05$ by the Tukey-Kramer multiple comparison test. NS: not significantly different among groups. Normal: normal control group; Control: low-fiber diet group; PAP257.5: Plantago asiatica powder (257.5 mg/kg)-treated group with low-fiber diet; PAP515: Plantago asiatica powder (515 mg/kg)-treated group with low-fiber diet (Central Lab. Animal Inc., Korea); STS500: sea tangle snack (500 mg/kg)-treated group with low-fiber diet; STS1000: sea tangle snack (1,000 mg/kg)-treated group with low-fiber diet.



Effects of sea tangle snack on fecal parameters in the rat model of low-fiber diet-induced constipation

In constipation, the fecal discharge decreased and fecal pellet transit delayed in the large intestinal lumen caused by absorption of water into the fecal pellets according to the markedly decrease the water content of the discharged feces. Therefore, these changes in fecal parameters, including discharged fecal pellet number and water content, have been used as indices of the effects of various laxative agents [15, 16]. To examine the effects of sea tangle snack on number of fecal pellets, wet weight of fecal pellets, and fecal water content in the low-fiber fed rats, constipation was induced in the rats by maintaining them on the low-fiber diet for 8 weeks. Then, Plantago asiatica powder (PAP257.5; 257.5 and PAP515; 515 mg/kg) as a positive laxative agent and sea tangle snack (STS500; 500 and STS1000; 1,000 mg/kg) were supplemented once daily for 2 weeks. The number of fecal pellets, wet weight of fecal pellets, and fecal water content are shown in Figure 2. Fecal pellet number during inducing constipation in the normal (40.30 count/day) was significantly different from that of the control group (20.30 count/day), suggesting the induction of low-fiber diet-induced constipation. After inducing constipation, fecal pellet number in the PAP515 and STS1000 groups (27.26 and 24.55 count/day, respectively) was significantly increased compared to that of the control group (18.63 count/day) (Figure 2A and B). Similarly, wet weight of fecal pellets in the control group was markedly decreased than the normal control group during and after inducing constipation. On the other hand, wet weight of fecal pellets in the PAP515 and STS1000 groups (2.71 and 2.59 g/day, respectively) was significantly increased compared to that of the control group (2.05 g/day) after inducing constipation by supplementation with Plantago asiatica powder or sea tangle snack (Figure 2C). In a previous study, it has been reported that oligosaccharides supplementation markedly increased the fecal number and wet weight of fecal pellets in loperamide-treated rats [12]. Niwa et al. [14] reported that the fecal number and dry weight were significantly decreased by treating with morphine in rats, but increased by the apple fiber supplementation in a dose-dependent manner. Zhu et al. [17] reported that the feces were dry, small, hard without burnish and the number and moisture content of feces decreased in rats after oral gavage of atropine diphenoxylate, whereas they increased by treatment of glucosides of paeony. Kakino et al. [18] also demonstrated that low fiber diet for 5 weeks significantly decreased stool frequency, weight, and water content, whereas 600 mg/kg agarwood (Aquilaria sinensis) administration significantly increased stool frequency, weight, and water content and markedly accelerated gastrointestinal motility in rats. Moreover, it has been reported that the fecal pellet number and water content marked decreased by induction of constipation in the rats, whereas these conditions were significantly alleviated following the administration of fermented rice extract when compared with the loperamide treated rats [19]. In general, low-fiber diet-induced constipation relates to fecal consistency, because fecal consistency depends on the ratio of the water-holding capacity of the insoluble solids, such as dietary fibers. It has been reported that dietary fiber swelled feces by its water-holding effect and improved bowel movement [18, 20]. As shown in Figure 2D, fecal water content of normal control group was significantly different from that of the control group. In addition, the fecal water content showed a tendency to increase in the PAP and STS group in a dose dependent manner after inducing constipation. These findings indicated that the preventive effect on constipation induced by low-fiber diet was due to the water-holding effect of sea tangle snack enriched in dietary fiber.

Figure 2: Effects of sea tangle snack on fecal parameters in the rat model of low-fiber diet-induced constipation. (A) fecal pellets number, (B) characters of feces, (C) wet weight of fecal pellets, and (D) fecal water content. Values are means ± SEM (n = 10). Values not sharing a common letter are significantly different at P < 0.05 by the Tukey-Kramer multiple comparison test. NS: not significantly different among groups. Normal: normal control group; Control: low-fiber diet group; PAP257.5: Plantago asiatica powder (257.5 mg/kg)-treated group with low-fiber diet; PAP515: Plantago asiatica powder (515 mg/kg)-treated group with low-fiber diet; STS500: sea tangle snack (500 mg/kg)-treated group with low-fiber diet; STS1000: sea tangle snack (1,000 mg/kg)-treated group with low-fiber diet.

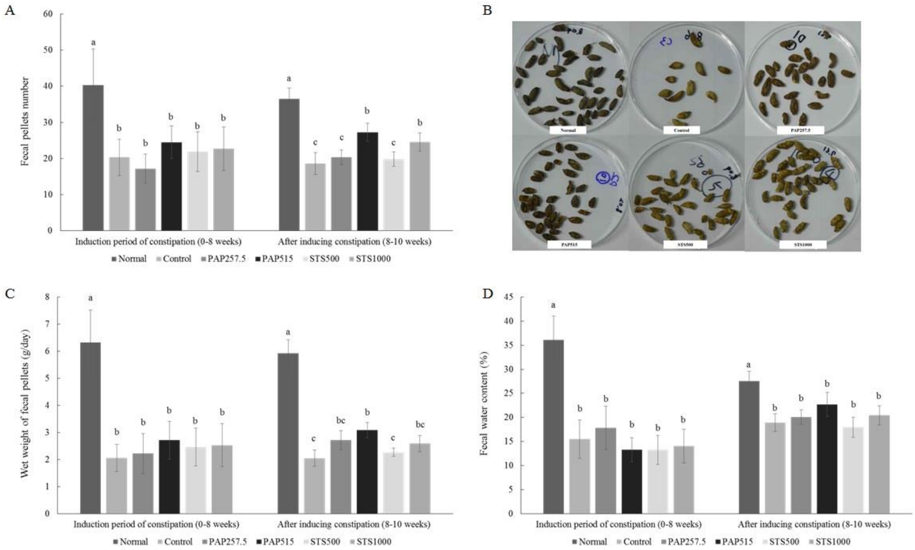


Figure 2

CONCLUSIONS

In conclusion, sea tangle (Laminaria japonica) snack supplementation showed a laxative effect on rats with low-fiber diet-induced constipation with no side effects. These findings suggest that sea tangle snack may be useful as a functional foods to prevent the constipation in humans. Further studies are also required to elucidate whether sea tangle snack causes a healing effect in constipation induced by other factors such as metabolic or endocrine disorders and side effects of medication.

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REFERENCES

[1] Mostafa SM, Bhandari S, Ritchie G, Gratton N, Wenstone R. Br J Anaesth 2003; 91: 815–819.
[2] Siegers CP, von Hertzberg-Lottin E, Otte M, Schneider B. Gut 1993; 34: 1099–1101.
[3] Kim SJ, Woo SN, Yun HY, Yum SS, Choi ES, Do JR. Food Sci Biotechnol 2005; 14: 798–802.
[4] Okai Y, Higashi-okai K, Nakamura S. Mutat Res 1993; 303: 63–70.
[5] Wang Y, Tang XX, Yang Z, Yu ZM. J Environ Sci (China) 2006; 18: 543–551.
[6] Park PJ, Kim EK, Lee SJ, Park SY, Kang DS, Jung BM, Kim KS, Je JY, Ahn CB. J Med Chem 2009; 12: 159–166.
[7] Jaswir I, Tope AHT, Raus RA, Monsur HA, Ramli N. Food Hydrocolloid 2014; 42: 275–279.

[8] Oh HK, Lim HS. Journal of the Korean Society of Food Science and Nutrition 2007; 36: 720–726.
[9] Park MJ, Ryu HK, Han JS. Journal of the Korean Society of Food Science and Nutrition 2007; 36: 1391–1398.
[10] Vandenbossche J, Huisman M, Xu Y, Sanderson-Bongiovanni D, Soons P. J Pharm Pharmacol 2010; 62: 401–412.
[11] You JS, Sung MJ, Chang KJ. Nutr Res Pract 2009; 3: 307–314.
[12] Han SH, Hong KB, Kim EY, Ahn SH, Suh HJ. Nutr Res Pract 2016; 10: 583–589.
[13] Shimotoyodome A, Meguro S, Hase T, Tokimitsu I, Satake T. Comp Biochem Physiol 2000; 126: 203–211.
[14] Niwa T, Nakao M, Hoshi S, Yamada K, Inagaki K, Nishida M, Nabeshima T. Biosci Biotechnol Biochem 2002; 66: 1233–1240.
[15] Wintola OA, Sunmonu TO, Afolayan AJ. BMC Gastroenterol 2010; 10: 95.
[16] Wu D, Zhou J, Wang X, Cui B, An R, Shi H, Yuan J, Hu Z. J Ethnopharmacol 2011; 134: 406–413.
[17] Zhu F, Xu S, Zhang Y, Chen F, Ji J, Xie G. PLoS One 2016; 11(8): e0160398.
[18] Kakino M, Tazawa S, Maruyama H, Tsuruma K, Araki Y, Shimazawa M, Hara H. BMC Complement Altern Med 2010; 10: 68.
[19] Choi JS, Kim JW, Cho HR, Kim KY, Lee JK, Sohn JH, Ku SK. Exp Ther Med 2014; 8: 1847–1854.
[20] Stephen AM, Cummings JM. Gut 1979; 20: 722–729.