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Research Article

Colour Preservation of Salted *Gracilaria lemaneiformis* by Hot Water Extraction of the Formed Brown Materials

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Abstract: The browning of *Gracilaria lemaneiformis* during salting decreases the sensory quality and commercial value of this alga. This study determined whether or not hot water treatment preserves the colour of salted *G. lemaneiformis*. During hot water treatment, brown materials were dissolved in hot water and separated from *G. lemaneiformis*, which resulted in the recovery of the natural colour of the alga. The optimised colour preservation conditions were 100°C extraction temperature and 20 min extraction time. Hot water treatment can potentially preserve the colour of *G. Lemaneiformis*.

Keywords: Brown material, colour preservation, *Gracilaria lemaneiformis*, water extraction

INTRODUCTION

Gracilaria lemaneiformis of the family Gracilariaceae (Rhodophyta) is widely distributed in the marine environment; members of this family are principal sources of agar (Fan *et al*., 2012a). The commercial mariculture of *G. lemaneiformis* is currently a leading industry in China because of the high adaptability and rapid growth of this alga as well as its potential to improve the water environment and produce high agar concentration (Li *et al*., 2008). *G. lemaneiformis* exhibits anti-tumour (Fan *et al*., 2012a), immunomodulatory (Fan *et al*., 2012b) and anti-influenza virus (Chen *et al*., 2010) activities. This alga is also a popular food resource in China because of its unique flavour and rich nutrition.

G. lemaneiformis contains 14.65% sugar, 21% protein, 0.87% lipids and relatively high levels of vitamin C, iodine, phosphorus and zinc (Wen *et al*., 2006). As a highly perishable commodity, *G. lemaneiformis* starts deteriorating immediately after harvesting. Thus, fresh *G. lemaneiformis* must be processed to extend its shelf life for off-season use. Salting is a common preservation method. However, *G. lemaneiformis* browning during salting and storage decreases the sensory quality and commercial value of the salted products.

We previously reported that the formed brown materials can be dissolved in hot water. Therefore, we determined whether or not hot water treatment preserves the colour of salted *G. lemaneiformis* and optimised the extraction conditions.

MATERIALS AND METHODS

Materials: Salted *G. lemaneiformis* was purchased from a local farmer market in Xinpu, China.

Treatments of the salted *G. lemaneiformis*: Salted *G. lemaneiformis* (10 g) was added to a beaker containing 100 mL of tap water. The beaker was maintained in a thermostatic water bath or a steriliser at 100°C for 20 min. The reaction mixture was filtered and the filtrates were subjected to colour evaluation.

Colour determination: The colours of the extracts were measured using a CR-400 Minolta chromometer at room temperature. The colour of each extract was measured thrice using the CIE Lab L^*(lightness), a^* (redness-green) and b^* (yellowness-blue) system. The changes in the colours of the extracts can be expressed as a single numerical value, ΔE, which defines the magnitude of the total colour difference as follows (Aguiló-Aguayo *et al*., 2009):

$$\Delta E = [(a - a_0)^2 + (b - b_0)^2 + (L - L_0)^2]^{1/2} \quad (1)$$

where a_o, b_o and L_o are the CIE-Lab values of tap water.

Statistical analysis: All tests were performed in triplicate and data are reported as means ± SD.

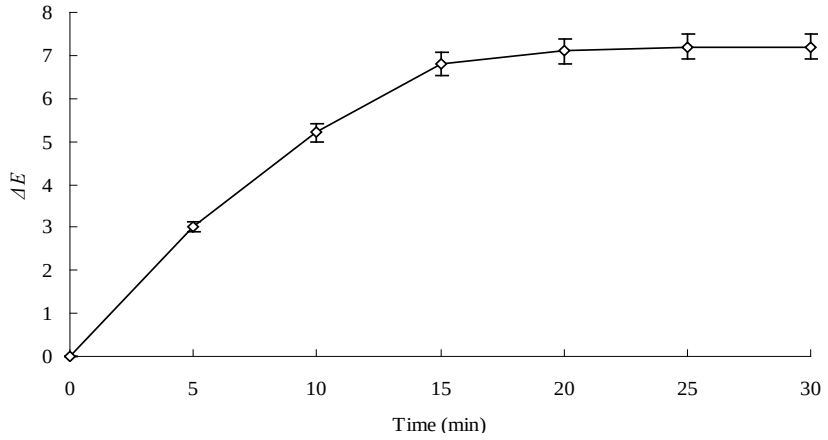

Fig. 1: Effect of time on the hot water extraction of brown materials in salted *Gracilaria lemaneiformis*

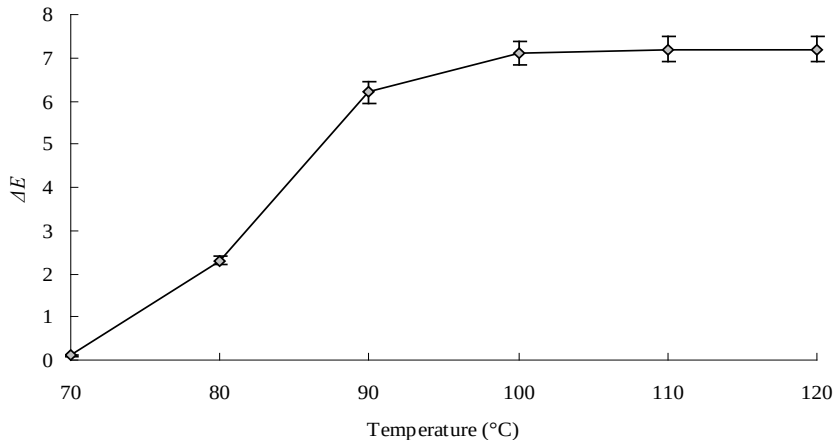

Fig. 2: Effect of temperature on the hot water extraction of brown materials in salted *Gracilaria lemaneiformis*

Variance and significant differences among means were tested by one-way ANOVA using SPSS software (version 17.0 for Windows, SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

Effect of time on the hot water extraction of brown materials: Time is important for the efficient extraction of brown materials in salted *G. lemaneiformis*. Therefore, time-course extraction of brown materials in salted *G. lemaneiformis* was performed for 30 min (Fig. 1). The *ΔE* value rapidly increased within 15 min gradually increased from 15 min to 20 min and did not further increase after 20 min. This phenomenon indicated that the brown material concentrations in the extracts and salted *G. lemaneiformis* reached equilibrium. Therefore, the optimal extraction time was 20 min.

Effect of temperature on hot water extraction of brown materials: Temperature crucially affects the hot water extraction of brown materials in salted *G. lemaneiformis*. Hot water extractions were performed at 70°C to 120°C (Fig. 2). Almost no brown material could be extracted at 70°C, which indicated the very low solubility of the brown materials in salted *G. lemaneiformis* at this temperature. The *ΔE* value moderately increased from 70°C to 80°C, which suggested that a few of the brown materials in salted *G. lemaneiformis* could be dissolved at 80°C. However, the *ΔE* value sharply increased from 80°C to 90°C, which indicated that most of the brown materials in salted *G. lemaneiformis* could be dissolved at 90°C. The *ΔE* value slightly increased from 90°C to 10°C and did not increase after 100°C, which showed that all

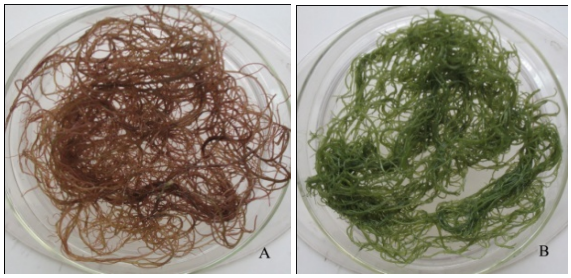

Fig. 3: Colour quality of the treated *Gracilaria lemaneiformis* and control sample

brown materials in salted *G. lemaneiformis* could be dissolved at temperatures above 100°C. Therefore, the optimal extraction temperature was 100°C.

Effect of hot water on the colour preservation of *G. lemaneiformis*: Under optimum extraction conditions, i.e., 20 min extraction time and 100°C extraction temperature, the colour of salted *G. lemaneiformis* returned from brown (Fig. 3A) to green (Fig. 3B), i.e., the original colour of fresh *G. lemaneiformis*. At the same time, the colour of the extracts turned from the original achromaticity to brown. This result indicated that the brown materials in the salted *G. lemaneiformis* could be dissolved in hot water at 100 °C.

CONCLUSION

The brown materials in salted *G. lemaneiformis* could be dissolved and extracted using hot water treatment. The efficiency of the extraction of the brown materials in salted *G. lemaneiformis* was affected by extraction time and temperature. Under optimum extraction conditions, salted *G. lemaneiformis* returned to its original green colour. Thus, hot water treatment may potentially preserve the colour of salted *G. lemaneiformis*.

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Conflict of interest: The authors declare no conflict of interest.

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