Review: Potential of Using Seaweed Silage Inoculated with Lactic Acid Bacteria and Its Impact Towards Sustainable Animal Feed

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Abstract

Since ancient times, seaweed has been used to supplement animal feed in coastal areas. In recent years, there has been a growing demand for seaweed as an animal feed. Effective preservation methods are required because of annual variations in seaweed availability and biochemical composition. Ensiling could be an effective method to preserve seaweeds for animal feed applications. Using lactic acid bacteria is a substitute biological technique for keeping and restoring the usual physiological state of the animal and increasing efficiency. The aim of this review is the potential of using lactic acid bacteria as an inoculant for seaweed silage for the development of sustainable animal feed. According to the microbiological point of view, the results in this area are weak, and limited information is available. Due to its high nutritional content, seaweed silage is a promising animal feed ingredient and is getting acceptance as an alternative animal feed. Therefore, seaweeds contain valuable metabolites such as polyunsaturated fatty acids, carotenoids, phlorotannins, carrageenan, alginate pigments, agar, and minerals (manganese, iodine, calcium, iron, selenium, sodium, zinc) are used as a natural antibiotic source in animal feed. In conclusion, increasing the use of effective lactic acid bacteria as an inoculant in animal feed can make the livestock sector more productive, safer, and friendly to humans and the environment, contributing to animal feed's long-term development.

Introduction

Global seaweed production more than doubled from 14.7 million tonnes in 2005 to 30.4 million tonnes in 2015, and it is still growing at a 6% yearly rate (Smith et al. 2018). Seaweeds are an adaptable natural resource with various uses, including biofuels, feeds, cosmetics, fertilizers, and medicines, among others. Although the vast majority is now used for human feeding, either directly or indirectly (through the production of agar, alginates, and carrageenan), seaweeds are still primarily used for human consumption. (Buschmann et al., 2017). There has been renewed interest in using seaweeds as an animal feed ingredient in recent years due to (i) their nutritional content in protein, complex carbohydrates, cheated minerals, bioactive compounds, and polyunsaturated fatty acids which may exert relevant biological activities (Evans & Critchley, 2014). (ii) their low reliance on chemical inputs , freshwater and land (Buschmann et al., 2017), (iii) their possibility to reduce ruminal methane emissions when included in ruminant formulations (Maia et al., 2016) . Seaweeds can be divided into three types based on the pigmentation: red (*Rhodophyceae*), green (*Chlorophyceae*) and brown (*Phaeophyceae*). Ensiling is a fermentation technology that is frequently used in terrestrial livestock feeds. This practise is especially significant in temperate climates because it provides a less weather- and energy-dependent alternative to dried forages (Borreani et al., 2008) . The current state of information regarding the possibility of ensiling seaweeds for animal feed is limited. A recent study discovered significant species-related variances in seaweed ensilability as a source of ruminant feed (Cabrita et al. 2017). Due to a high buffering capacity, the presence of complex carbohydrates that are resistant to microbial deterioration, and a dearth of naturally occurring lactic acid-producing microflora in fresh seaweeds, other authors discovered limitations in the scope of a suitable lactic acid fermentation of seaweeds. (Herrmann et al., 2015). The aim of this review is the potential of using lactic acid bacteria as an inoculant for seaweed silage for the development of sustainable animal feed.

Effectiveness of using seaweed silage as animal feed

Because of several advantages, seaweed is gaining popularity as an alternative to lignocellulosic substrates. First, they are high in carbohydrates; second, they are not a primary food crop and lack lignin, making saccharification more workable; and third, seaweed has a short generation cycle and can be easily cultivated in various forms of aquatic environments. Seaweed silage produced via complex bio-process can enhance product development and enrich seaweed with good mineral and nutrition value is suitable for consideration as novel feed silage. (Uchida et al., 1997) introduced a new method, where they convert seaweed into silage using lactic acid bacteria to enhance the nutritional benefit of the silage by improve minerals, vitamin, protein, fatty acids, organic acid, essential amino acid, and reduced the material size of the seaweed at single cell detritus. In addition, lactic acid bacteria inoculated with seaweed silage are added as growth promoter, immune enhancer and probiotics in cultivable organisms**.**

Nutritional Value of Seaweed

The nutritional richness of microalgae, combined with their nonanimal nature, makes them especially suitable for animal feed as nutraceuticals, a term derived from the combination of nutritional and pharmaceutical, used to identify dietary components that provide health advantages, including disease prevention (Pomin, 2012) . In vitro studies and certain animal studies have supported the health advantages of seaweed beyond the provision of vital nutrients; however, many of this research used inadequate biomarkers to validate a claim and did not move to appropriately designed trials to evaluate efficacy. Some seaweed components are appealing as functional food ingredients based on the limited evidence available, but more animal nutritional studies evidence (including mechanistic evidence) is required to evaluate both the efficacy of purported bioactivities and the nutritional benefit conferred, as well as any potential adverse effects (Morais et al., 2020).

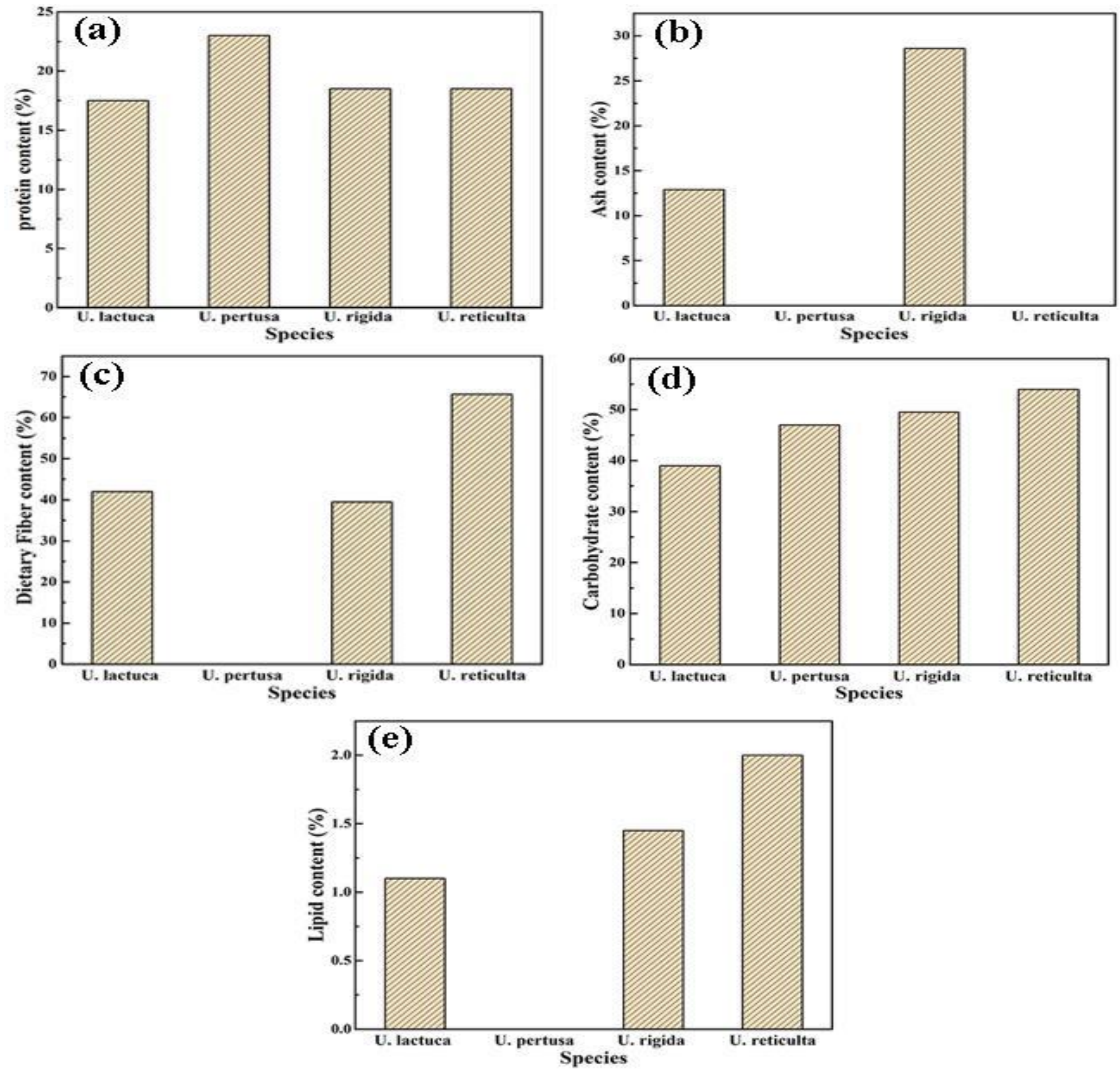

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Figure 1. Nutrient composition of green seaweeds (Morais, et al. 2020), (A) protein content, (B) Ash content, (C) Dietary Fiber, (D) Carbohydrate content, (E) Lipid content.

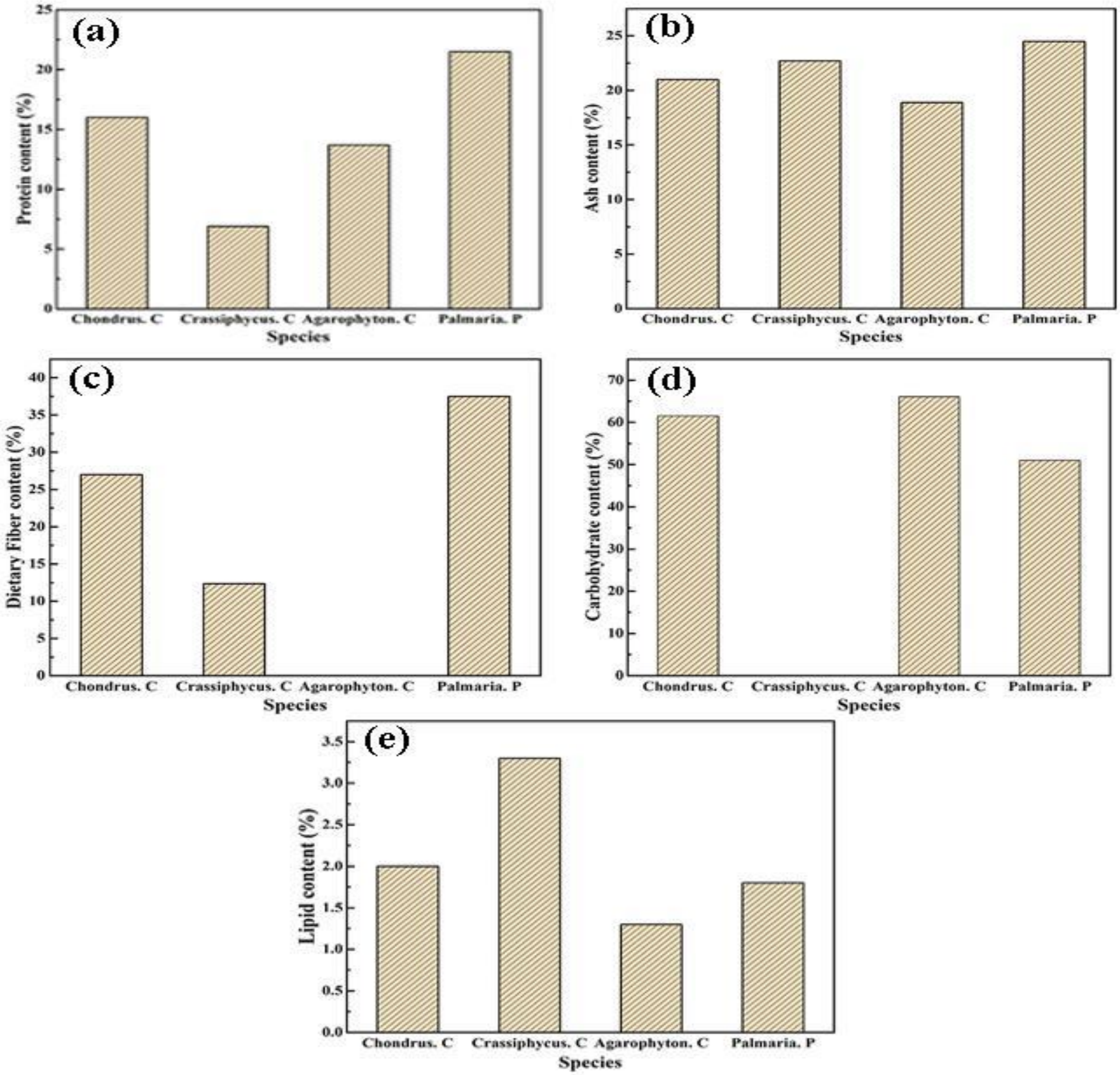

Figure 2. Nutrient composition of red seaweeds (Morais, et al. 2020). (A) protein content, (B) Ash content, (C) Dietary Fiber, (D) Carbohydrate content, (E) Lipid content.

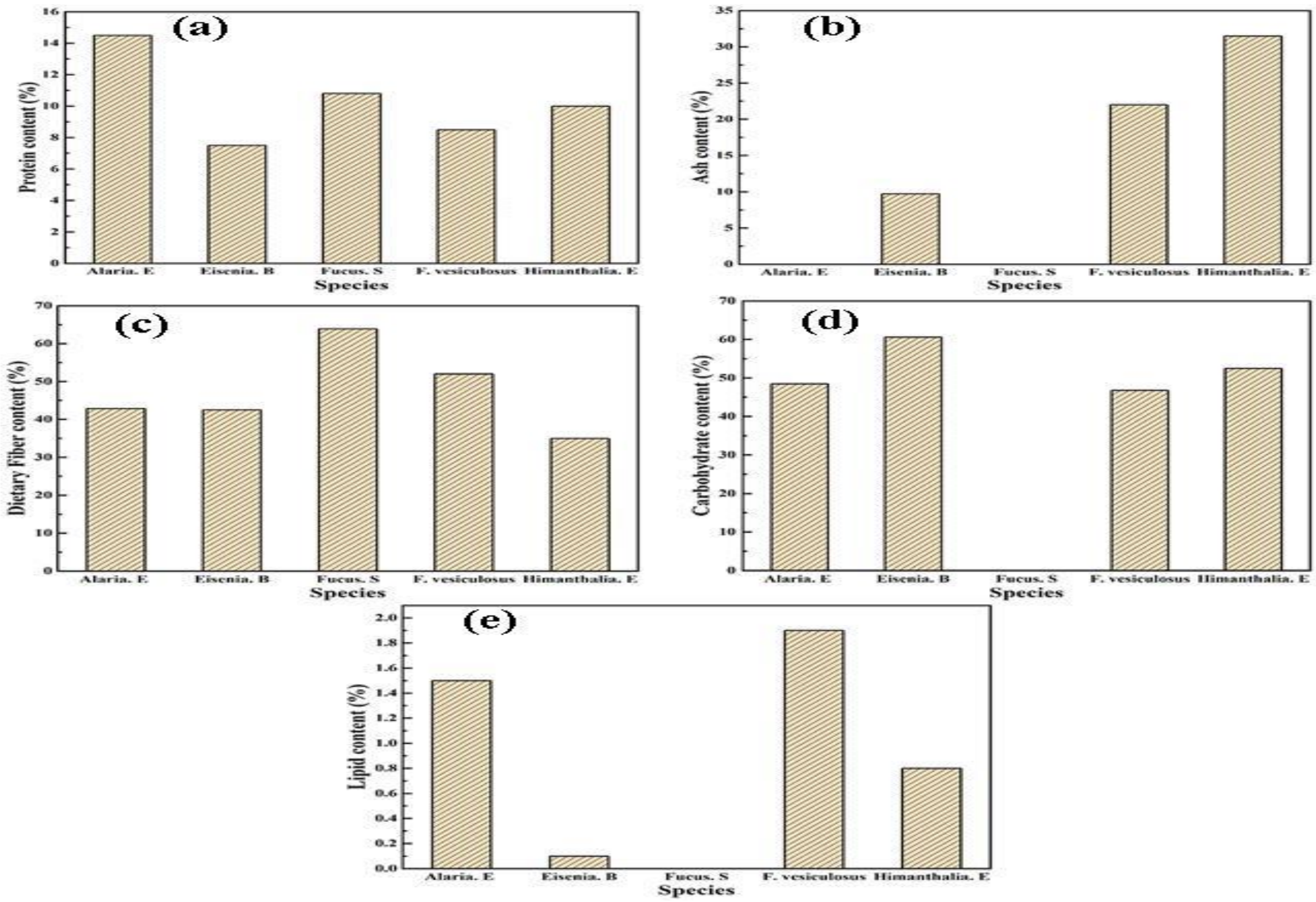

Figure 3. Nutrient composition of brown seaweeds (Morais, et al. 2020). (A) protein content, (B) Ash content, (C) Dietary Fiber, (D) Carbohydrate content, (E) Lipid content.

Feed Safety

Seaweed is regarded as a rich and supportable source of macronutrients for livestock feed, nevertheless, if seaweeds are to contribute to global food security in the future. To protect opposed to immoderate intakes of salt, iodine, and heavy metals such as cadmium (Cd), arsenic (As), rubidium (Rb), aluminium (Al), strontium (Sr), lead (Pb), tin (Sn), and silicon, legislative measures requiring labelling and monitoring of feed products are required (Chen et al., 2018) . However, heavy metal absorptions in seaweeds are usually under toxic levels, bioaccumulation of lead and arsenic is the key risk in wild seaweed harvesting. More research into heavy metal toxicokinetics is necessary to address the issue.

Ruminant Feed

The growing demand for animal feed protein, the need for alternatives to standard soybean, animal protein feed, and food market rules governing livestock feeding have all influenced the usage of seaweed in ruminant diets. To date, studies on the use of seaweed in bovine, caprine, and other ruminant nutrition have concentrated on adding small amounts of different macroalgal species to feed and then assessing the animal for probable prebiotic activity and improved animal performance. There is little information on the use of green seaweeds in ruminant feed. Sheep consume seaweed in sufficient quantities to meet their maintenance needs, however they suffer from mineral overload due to its high mineral content (Makkar et al., 2016).

Some studies have also suggested that up to 30% Macrocystis pyrifera can be used as a supplement in goat feed without compromising digestibility, degradability, or ruminal fermentation characteristics (such as pH and ammoniac nitrogen). Currently, it can be included in the diets of growing sheep and goats at up to 30% without affecting intake, growth performance, or diet digestibility (Pereira & Yarish, 2008) . There is numerous research that must be conducted in order to support seaweed as a feed supplement in ruminants.In conclusion, increasing the use of effective lactic acid bacteria as an inoculant in animal feed can make the livestock sector more productive, safer, and friendly to human and environment then contributing to the long-term development of animal.

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