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Spartina green food ecological engineering¹

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Abstract

Spartina green food ecological engineering can produce various ecological and economic benefits. Not only can the biomineral liquid with a number of health functions (cardiotonic, antiinflammation, enhance of immunity, lengthening of life span) be extracted from *Spartina* culms, but also, the total flavonoids of *Spartina* can be separated, which can significantly resist blood coagulation and encephalon thrombus. The grass residue can be used to culture mushrooms. The practice showed that economic benefits from this engineering are huge. During 1991–1995, the new output values were about 112 million yuan RMB and the new profits were up to 30 million yuan RMB. We plan to develop fourth level benefit from the mushroom culture residue and to exploit more benefits from the engineering. © 1998 Elsevier Science B.V. All rights reserved.

Keywords: Ecological benefit; Economic benefit; *Spartina alterniflora*; *Spartina* extract; Flavonoids

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1. Introduction

Dr Chung-Hsin Chung introduced *Spartina anglica* in 1963 and *S. alterniflora* in 1980 to People's Republic of China, and so far the two species of *Spartina* have been developed to 40000 ha (Qin and Chung, 1992). Before 1985 we had exploited *Spartina* plantations for natural and ecological applications, such as in accretion for reclamation, amelioration of saline soils, green manure, animal fodder and especially in seashore stabilization (Chung, 1990). Since 1985 we have developed more uses of *Spartina* including its food uses and grass residue uses which in return enhance *Spartina* ecological engineering. The design is that human society and the natural environment can benefit each other (Mitsch, 1988), and enhance the practical values from *Spartina*. This paper will introduce the design of *Spartina* food ecological engineering and its ecological and economic benefits.

2. Materials and methods

2.1. Site of studies

Dafeng city of Jiangsu province, a famous ecological city, lies 33.2°N, 120.5°E and belongs to the warm temperature zone with monsoon climate. One of our *Spartina alterniflora* plantations, which we have worked on for 11 years, and is the site in this study, is along the coastal tidal land from Wanggang to Zhugang estuary, Dafeng city. The plantation was transplanted during 1985–1987 and has developed over 1000 ha so far.

2.2. Ecological engineering design

Spartina green food ecological engineering tests began in 1987 and since then the engineering has been improved. The major feature of the engineering is multi-level development of effective contents from the grass for food uses. First, by a special production procedure the engineering can provide three materials from the original grass. There are two products: biomineral liquid (BML) and total flavonoids of *Spartina* (TFS), and the rest comes from the grass residue in the procedure. These three materials can be used to develop various foods: a series of biomineral products from BML, health foods or drugs from TFS, and mushrooms and fodder's from the grass residue (Fig. 1).

2.3. BML preparation and functional tests

2.3.1. BML preparation procedure

In autumn *Spartina* culms are cut, cleaned and smashed for its extract production. The simple procedure in production is as follows: soaking the culm's fragment in boiling water for 1 h and then concentrating the thin extract to a special dark brown liquid with special gravity of 1.25. That liquid is the *Spartina* extract named biomineral liquid (BML) (Qin and Xie, 1988).

2.3.2. Enhancing people's immunity tests of BML

A total of 120 subjects were randomly divided into four drinking groups: Group 1, drinking normal water; group 2, drinking 'Jianlibao water' (a famous Chinese drink); group 3 and 4, drinking two kinds of biomineral water (BMW, which is produced by BML). After 1 month of testing, the lysozyme contents of saliva were examined from each subject. Also the phagocytic rate of polymorphonuclear leukocyte was examined for all subjects after the test (Jiang and Qin, 1992).

2.3.3. Cardiotonic function tests of BML

A total of 40 mice (half male and half female) were randomly divided into two drinking groups: control group was drinking normal water and the BML group was drinking diluted BML (1:400). After testing for 4 weeks these test animals were dissected, the hearts were removed and put into normal saline solution. The pulse and pulse's duration were counted for each.

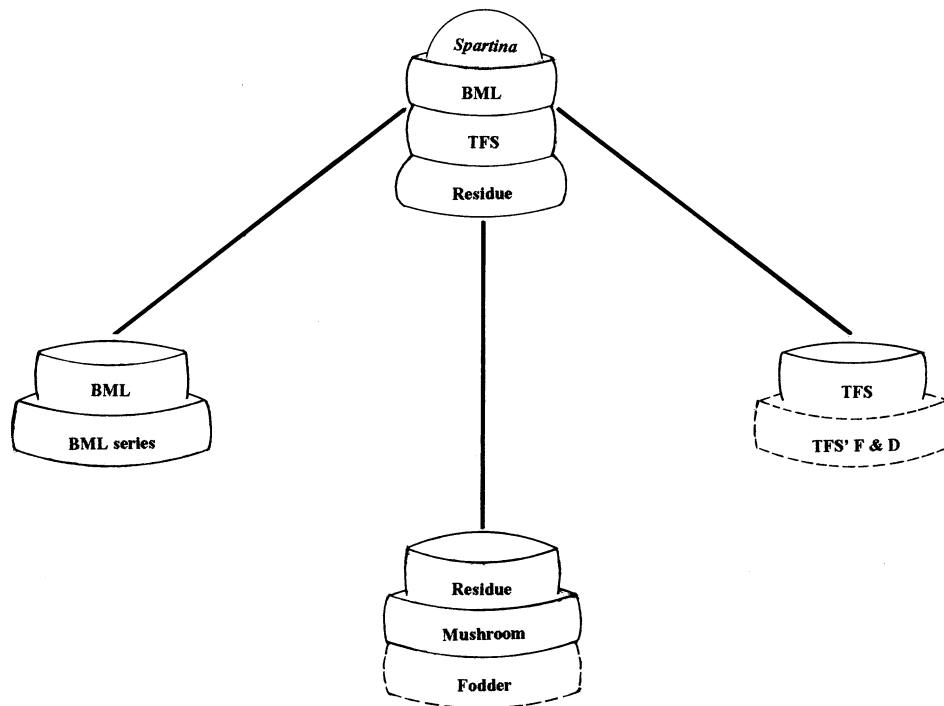


Fig. 1. The design sketch of *Spartina alterniflora* green food ecological engineering. BML, biomineral water; TSF, total flavonoids of *Spartina*.

2.4. TFS preparation and functional tests

2.4.1. TFS preparation procedure

In BML production the solid part can be separated from BML by centrifugation. Using the method of alkali-solution and acid-precipitation, TFS can be separated from the solid (Qin and Xie, 1992).

2.4.2. Fibrinolysis activity test of TFS

Taking SD rats (male) weighing 270 ± 15 g, blood samples were collected from the vein in their canthus to make the oxalate plasma of rats (blood: anticoagulant = 9:1). The plasma and the soaking liquid of rabbit's brain powder were put into several 0.1-ml test tubes. After the plasma coagulum formed, TFS dilutions of 2-, 4-, 8-, 16-, and 32-fold and the control (0.15 NaCl Tris-HCl buffer, pH 7.3), were added to every tube, respectively and the tubes were cultured at 37°C for 24 h, then examined for changes in these coagulums.

2.4.3. Resisting encephalon thrombus test of TFS

A total of 100 mice weighing 25 ± 1.0 g were divided into four groups and injected with TFS1 (60 mg kg^{-1}), TFS2 (15 mg kg^{-1}), aspirin (2.0 mg kg^{-1}) and control (normal saline water), respectively. After treating for 5 min with 0.1 ml of the thrombus inductor (glutin 1.4 mg ml^{-1} , adrenaline $60 \text{ } \mu\text{g ml}^{-1}$) the dead and the survivors were examined.

2.5. Grass residue use tests

2.5.1. Mushroom culturing test

The grass residue, lime, wheat bran, 'dojunlin' (a wide bactericide) and the mushroom's seed (second grade) were mixed with the prescription, 100:1:5:0.4:15–25. Water was added and the content was adjusted to 60% in the culture medium. The medium was pressed as a block form and wrapped with a plastic membrane in a room and cultured at 20°C. The mushroom was harvested after 50 days. The medium was pressed and put on a soil bed (length:depth, 4:1 and 0.3 m below the ground), keeping the mushroom bed under a plastic shield from low temperature, culturing it at natural conditions.

2.5.2. Medium residue use tests

To protect the environment and increase the resource development benefit in ecological engineering we plan to design the use of the last grass residue (after mushroom harvesting) for fodder. It should be done to analyze the nutrients of the last residue. Iodometry titration could be used for the analysis of cellulose content and anthrone colorimetry could be used to determine the sugar in the hydrolyzates (Huang, 1979).

Table 1
TFS fibrinolysis activity on SD rats

Groups	Dilution times	TFS concentration (%)	No. animals (<i>n</i>)	Fibrinolysis activity
Control		0	10	Not soluble
Treatment 1	2	0.6	10	All soluble
Treatment 2	4	0.3	10	All soluble
Treatment 3	8	0.15	10	Mostly soluble
Treatment 4	16	0.075	10	Partly soluble
Treatment 5	32	0.0375	10	Partly soluble

3. Results

3.1. Economic benefits from BML and its series products

BML contains more bioactive materials and minerals, so it can be used as a food additive. The toxicological research on BML showed that BML is safe to people and animals. So far there has been a series of products in the People's Republic of China. In 1991–1995, the new output and profit of BML were 11.8 and 3.33 million yuan, respectively and the new output and profit of biomineral series was 111.72 and 29.92 million yuan, respectively.

3.2. Increase in human immunity

The immunity-index examining test showed that BML increased not only the lysozyme content of human saliva (Fig. 2A), but it also increased the phagocytic rate of human polymorphonuclear leukocyte in vitro (Fig. 2B). An *F*-test showed that, BML's function of increasing immunity was significantly higher than that of the Jianlibao ($P < 0.01$).

3.3. BML has cardiogenic function on animals

Through cardiogenic tests on mice, it was discovered that longer pulses duration occurred in the treated than that in the control. Statistical analysis of free heart pulses showed that both male and female of the treated mice had significantly more counts than that of the control.

3.4. Fibrinolysis activity of TFS

The fibrinolysis activity tests on rats showed that TFS dilutions of 2-, 4-, 8-, 16-, and 32-fold all had very good fibrinolysis activity but the control did not have this activity in the test condition (Table 1).

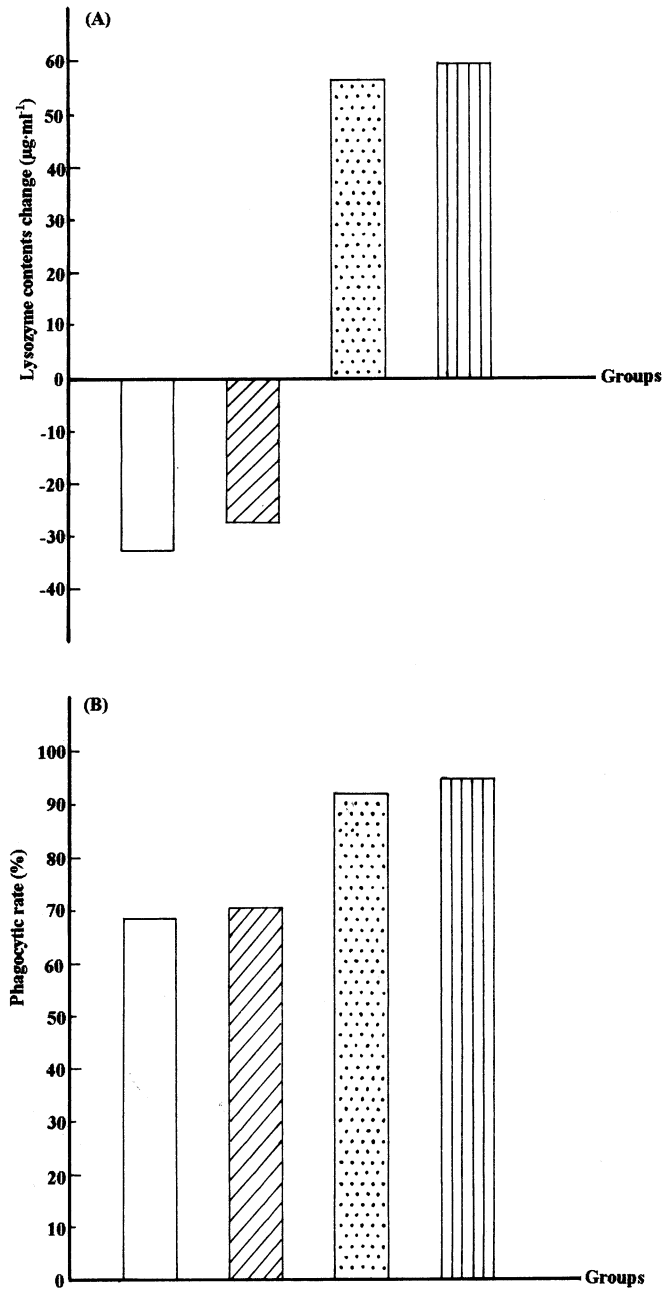


Fig. 2. Two human immunity indexes in four groups. (A) Change in lysozyme contents of human saliva in four groups before and after test; (B) phagocytic rate of polymorphonuclear leukocyte among four groups of people in vitro. □, group of normal; ▨, group of 'Jianlibao'; ▤, group of BMW1; and ▧, group of BMW2.

Table 2
TFS resisting encephalon thrombus of mice

Groups	Route	Dose (mg kg ⁻¹)	No. animals (<i>n</i>)	Survivals	Protection rate (%)
Control	i.v.	0	25	3	16.7
Aspirin	i.v.	2.0	25	5	27.8*
TFS1	i.v.	15	25	6	33.3*
TFS2	i.v.	60	25	12	66.7**

By *F*-test, * comparison with control, $P < 0.01$; ** comparing with aspirin group, $P < 0.01$.

3.5. Resistance of TFS to encephalon thrombus

The resisting encephalon thrombus test of TFS showed that TFS1 (15 mg kg⁻¹) and TFS2 (60 mg kg⁻¹) were the effective dose for resisting the encephalon thrombus of mice induced by glutin. Among these, TFS1 had the same protection rate on animals as aspirin (2.0 mg kg⁻¹), and TFS2 was better than the others (Table 2).

3.6. Economic benefit of mushroom

The mushroom culturing test showed the grass residue was adaptable to the mushroom's culture and could continue providing economic benefit using both culture methods (Table 3). It was obvious that the output and profit of the wrapping block method was better than that of the soil-bed method during the three seasons in 1994–1995.

3.7. The last residue's nutrition

Nutrient analysis of the last residue showed some nutrients of the last residue were higher than that of the extracted residue, e.g. crude protein and cellulose, because the mushroom culture had fungi protein and cellulose and increased the nutrition level in the last residue (Table 4).

Table 3
The benefit of *Spartina* grass residue from the mushroom during different seasons in 1994–1995 (yuan kg⁻¹)^a

Culture methods	Autumn	Winter	Spring
In a room	3.0+0.11	1.6+0.07	2.7 ± 0.10
In a soil bed	2.6+0.09	1.5+0.07	2.4+0.08

^a Net profit of 1 kg of grass residue in the medium from the mushroom.

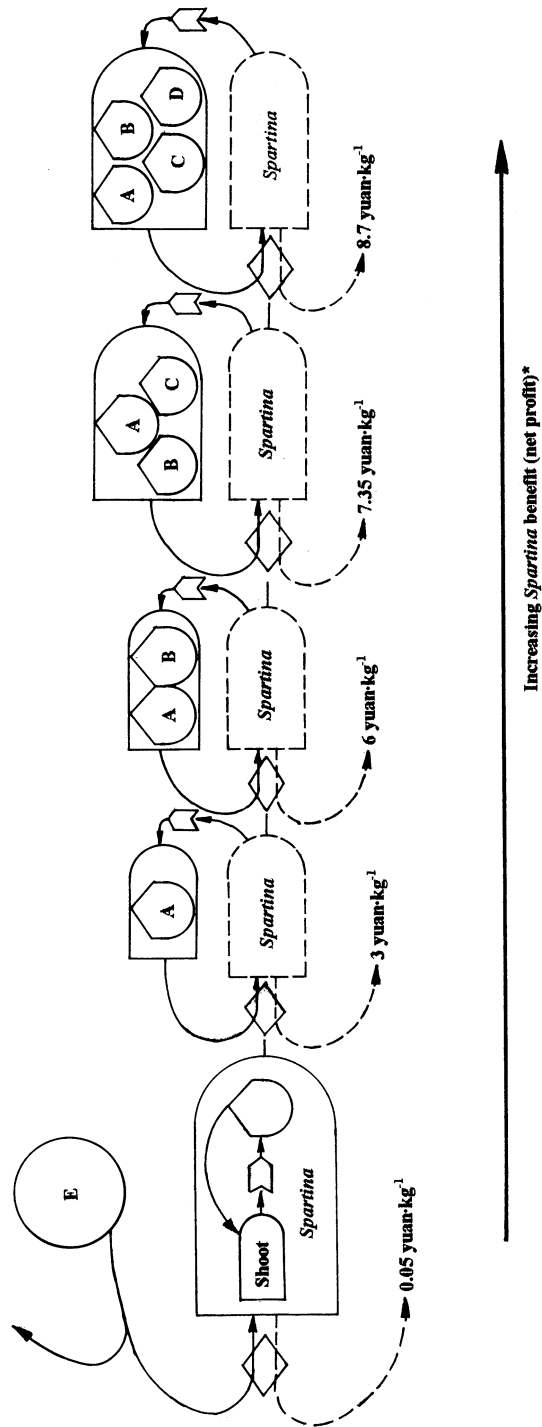


Fig. 3. The tendency of increasing *Spartina* benefit in the green food ecological engineering: A: BML (biomineral water); B: TFS (total flavonoids of *Spartina*); C: mushroom from residue; D: fodder from residue; E: resources. Qin et al., 1997.

Table 4
The analysis of *Spartina* grass residue's nutrients (%)^a

Residues	Crude protein	Cellulose	Other polysaccharide
Extracted residue	10.16+0.24	29.86+0.34	21.44+1.24
The last residue ^b	19.28+0.89	33.46+1.62	18.84±0.16

^a The residue analysis was sampled ten times in BML workshop in 1992.

^b Grass residue after harvesting mushroom.

4. Discussion

The energy system of *Spartina* green food ecological engineering belongs to a social economic-natural complex system (co-ecosystem) which is recognized as an organic whole (Ma and Wang, 1984, 1989). This system has three features. Firstly, this system is similar to a *Spartina* natural system which has energy resources of the sun, wind and tide. The necessary supplementary energy of the system is less and comes from fuel and electricity outside of this system. Secondly, this system is very economical and safe, because its major nutrients and organic matter are provided by the sea and river, and its waste material (the grass residue) could be digested by microorganisms and transformed into enjoyed products for humans and animals. Thus it can minimize the cost of measures and their harm to environment (Uhlmann, 1983; Straskraba, 1985). Thirdly, the ecological engineering design adds to this system, BML, TFS, and their series products. These green foods with high health functions decrease the energy loss from the dead grass of *Spartina* and develop the potential energy from the effective components of the grass. By the measure of saving money from seashore protection *Spartina* grass only creates the net profit 0.05 yuan kg⁻¹ (Qin et al., 1997). But if developed the series products using its effective components this grass could produce a greater profit, increased up to 60–200-fold (Fig. 3). Thus, the sustainable developed engineering will win more interest of many people with its more ecological-economic benefit.

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