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Application of Atmospheric Plasma Technology to Long-Grain Brown Rice Modification

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Abstract. Brown rice is simply white rice that has intact bran covering the rice grain. For this reason, it is a much better source of fiber compared to white rice. Moreover, brown rice itself is very rich in minerals, such as iron and magnesium, as well as in vitamins and natural fibers that help to lower LDL cholesterol and it also doesn't disturb the blood sugar level. While it is well-known that brown rice is more nutritious than well milled white rice, the outer seed coat contributes a definitely different texture which is disliked by many consumers.

Atmospheric plasma can produce very efficient sources of active species in air or in another gas or gas mixtures at atmospheric pressure. This project will utilize a dielectric barrier discharges system with adjustable frequency and voltage to produce non-thermal plasma at atmospheric pressure. The microstructure of long-grain brown rice surface and the cooking, textural, rheological properties of plasma treated brown rice are determined. The plasma treatment results in an etching of brown rice surface, which was observed by scanning electron microscopy. After plasma treatment, the cooking time of long-grain brown rice and hardness of cooked brown rice are reduced. Rheological parameters were influenced by plasma treatment. Thus, plasma treatment can be used to improve the cooking properties and quality of long-grain brown rice.

Keywords: atmospheric plasma, brown rice, modification

1. Introduction

Brown rice is less desirable from a consumer's perspective due to its longer cooking time and poor eating qualities. Cooked brown rice is unpalatable with its hard texture and chewiness, which are attributed to the tough fibrous bran layer. However, from a health perspective, brown rice is preferable because of its higher nutritional value [1].

Recently, plasma-processing procedures result in an etching of brown rice surface, which allows water to be easily absorbed by the rice kernel during soaking. After plasma treatment, the cooking time of brown rice is reduced, and the cooked brown rice has a soft texture and is easier to chew [2]. Such methods include the use of glow discharge for sterilization, deposition and etching of thin films, and increasing the surface energy of materials. Glow discharge plasma can produce high energy electrons and other highly active species at room temperature [3]. Other applications have been conducted at pressures below 1333 Pa, where stable glow discharge plasmas were easily generated by the application of a DC electrical field to the gap between two metal electrodes [4].

However low-pressure plasma need vacuum equipment, which can not run in line. This project will utilize a dielectric barrier discharges system with adjustable frequency and voltage to produce non-thermal plasma at atmospheric pressure. In this research, it was assumed that atmospheric plasma could result in the etching pattern on the surface of long-grain brown rice and thus change its properties. Long-grain (*Indica*) varieties are common in tropical regions, as many are drought tolerant, but do not tolerate colder temperatures. The grains are medium to long, narrow and flat [5]. The properties of long-grain

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brown rice after plasma treatment have been evaluated in this research, including the microstructure of the outer surface, as well as the cooking and physicochemical properties.

2. Materials and Methods

2.1. Materials

Rice (Oryza stativa L): Taichung Sen 10 (TCS10) in Taiwan

2.2. Methods

- Exposure of brown rice to plasma

A dielectric barrier discharge (DBD), non-thermal plasma at one atmosphere technology, was developed in this study. The plasma system is showed in Fig. 1.

- SEM
- Cooking properties
- Water absorption in soaking procedure
- Textural properties of cooked brown rice

3. Results

The design of atmospheric plasma is shown in Fig. 1. The previous research indicated that the cooking time of brown rice is reduced after low-pressure plasma treatment [2]. So, the cooking time is determined to assess the effect of atmospheric gas plasma on brown rice. The effects of voltage and exposure time of plasma on the cooking time of brown rice are illustrated in Fig. 2. After 4 kV, 4 min of plasma exposure, the cooking time reaches the minimum value (12.5 min).

Scanning electron microscopy (SEM) images of the outer surface of brown rice clearly revealed that plasma exposure resulted in the rice bran having an irregular and specific morphology (Fig. 3). After plasma exposure, the surface showed a pattern of shallow destruction.

The hydration curve of the rice kernel with plasma treatment during the soaking process is illustrated in Fig. 4. The hydration curves of brown rice with plasma treatment showed a rapid increase in the water content during the first 3 h of soaking. In addition, brown rice with plasma exposure had higher water absorption than regular brown rice during the first 3 h of soaking.

The texture of cooked rice texture has been shown to govern its acceptance by consumers when it is consumed as a whole grain. Hardness and Gumminess values of brown rice with plasma exposure were significantly lower than for untreated rice (Table 1).

This research has shown that plasma exposure effectively improved the cooking properties of brown rice by reducing cooking time and hardness of cooked brown rice. In addition, the change in the morphological structure of the rice bran layers and the increment in the quantity of water absorption demonstrated the effectiveness of plasma exposure brown rice was also evaluated. It was determined that utilization of atmospheric plasma provided a better textural quality and shortened the cooking time.

Fig. 1: Plasma apparatus.

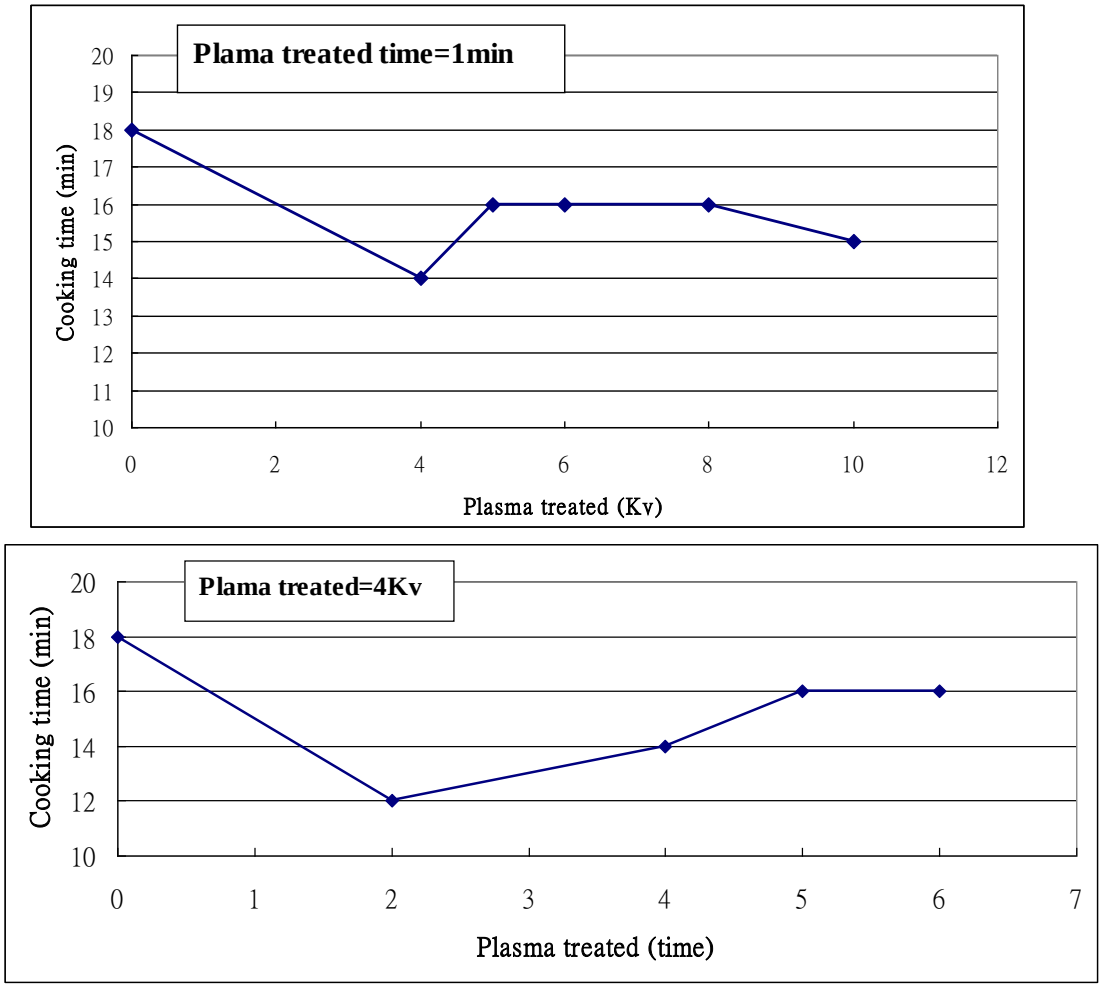

Fig. 2: Cooking time of native brown rice (control) and brown rice treated with plasma.

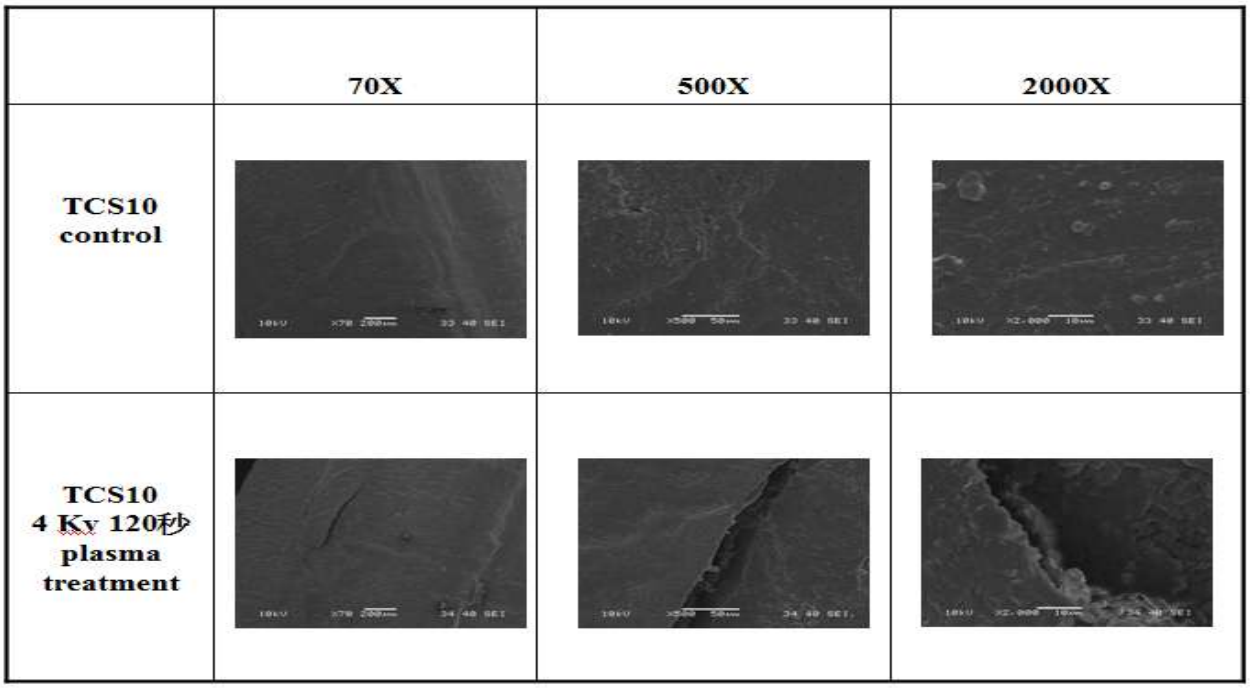

Fig. 3: SEM images of native brown rice (control) and brown rice treated with plasma.

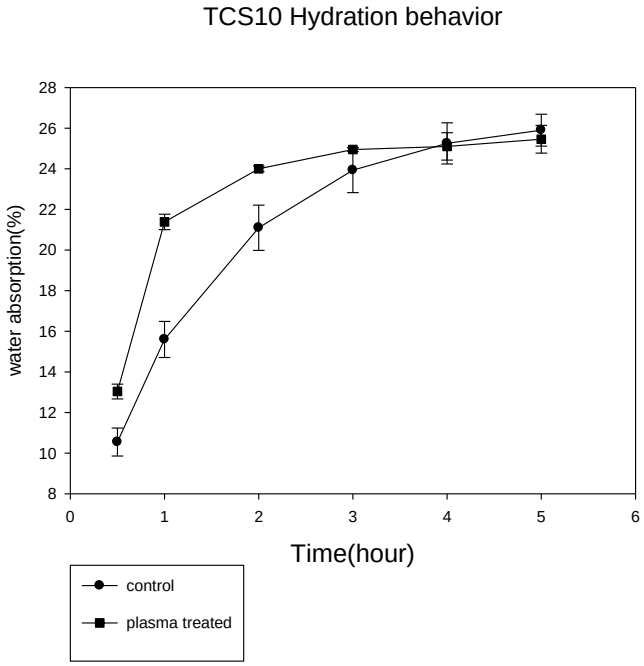

Fig. 4: Water absorptions of native brown rice (control) and brown rice treated with plasma.

Table 1. Textural properties of native brown rice (control) and brown rice treated with plasma.

	TCS10 control	TCS10 4 Ky 120 秒 plasma treatment
Hardness(n)	119.09	91.28
Cohesvieness	0.38	0.33
Gumminess(N*mm)	45.34	30.76
Chewiness(N*mm)	15.75	10.64
Elasticity(%)	34.48	34.26

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