

## Effects of soaking, steaming and vacuum microwave heating on structure and physical property of quick cooking Job's Tear

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### Abstract

Job's Tears is one of the most fruitful nutritional foods. However, it consumes a lot of cooking time prior to consumption. If the cooking time of Job's Tears could be reasonably reduced, it would be more convenient and an incentive to consumers to eat more Job's Tears. The main objective of this study is to reduce cooking time of Job's Tears by reducing its moisture with vacuum microwave heating. The experiments were conducted by soaking (6 and 7 h) and steaming (at 100°C for 20 and 30 min), after which the grains were dehydrated by vacuum microwave (60, 80 and 100% power). It was found that increased soaking and steaming times decreased percentages of water uptake and cooking time, whereas increasing the microwave power levels did not. The lightness ( $L^*$ ) changed significantly with increased soaking-, steaming- and power conditions. Scanning electron micrographs (SEM) showed the absolute change in starch granules, becoming more honeycomb-like in structure and formed fractures after strong treatment. Based on these results, the optimal treatment for precooked Job's Tears grains consisted of soaking for 7 h, steaming for 30 min and drying at 80% microwave power. By using these combining parameters, the reduction of the cooking time by about 53.3% while still maintaining good sensory qualities (data not shown), was achieved.

**Keywords:** Job's Tears, precooked, soaking, steaming, vacuum microwave

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### 1. Introduction

Some kinds of cereal grains such as Job's Tears (*Coixlachryma-jobi* L.) are generally consume as food supplement. It has been found that it contains polyphenol, antioxidants and unsaturated fatty acids [1, 2]. Therefore, it has been used in several traditional Chinese, Japanese and Indian medicines [3, 4, 5, 6]. The cultivation of Job's Tears areas are mainly located in Asia, including Thailand [6, 7], a country where it has been reported that Job's Tears exports value increased from 133,878,000 THB in 2013 to 142,429,000 THB in 2014. As a matter of fact, there is a ready -to- drink Job's Tears in the market. But the most frequent way to consume Job's Tear continues to be the fully edible form, e.g. Job's Tears cooked with sugar and soy milk [1]. Unfortunately, this kind of Job's Tears preparation is not very popular, as it requires a long cooking time which wastes amount of energy.

A review of the literature shows that the main techniques of the production of quick-cooking starch products consist of combining heat moisture treatment and drying processes [8, 9, 10, 11, 12, 13, 14]. The principle of this production technique is based on three main items, i.e., initial moisture content, the degree of gelatinization and the drying method [13]. The moisture content can be obtained by a soaking

and steaming process [14]. The degree of gelatinization depends on the cooking time [13], whereas the drying step is a function of the final moisture content [9, 13]. Swasdisevi *et al.* [11] studied the effects of pre-steaming time and drying air temperature on the production of partially parboiled rice and found that the pre-steaming and drying steps changed the rice color and the starch's pasting properties. Rewthong *et al.* [12] also reported that cooking, pretreatment with frozen storage of the rice at -20°C and refrigeration at 4°C, as well as the drying methods, affect the morphology and textural properties of instant rice. Schoeniger *et al.* [15] reported that a decrease of the cooking time of beans can be achieved by soaking and blanching beans in a NaHCO<sub>3</sub> solution. However, during the traditional drying processes many foods undergo different alterations, e.g., degradation of flavor and of nutritional constituents, low drying rates and long drying times [16]. The new drying methods have been developed, e.g., vacuum microwave heating, which is based on heating by a transfer of electromagnetic energy to thermal energy, resulting in low temperatures but still leading to rapid dehydration [16]. However, most of the vacuum microwave research has been carried out with dehydrated fruits and vegetables [17, 18, 19, 20, 21, 22]. Little studies have been made so far to apply this technology to dehydrate cereal products.

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The development of modern techniques for quick cooking of cereals, especially, Job's Tears, is still limited. As a matter of fact, some researchers reported that precooked Job's Tears was accomplished by combined soaking, steaming and freezing processes [23]. However, these procedures appear to be not very practical and require high expenditure investments. The present paper aims to report the effect of process on physical property and structure of quick cooking Job's Tears by using vacuum microwave heating.

## 2. Materials and methods

### 2.1 Material

Job's Tears (*Coixlachryma-jobi* L.) with an initial moisture content of 10 % (wet basis) was obtained from Choomsin Food Industrial Co., Ltd., Nonthaburi province, Thailand. It was sealed in a vacuum bag and vacuum stored at an ambient temperature (30±35°C).

### 2.2 Soaking and steaming conditions

The experiment was an adapted method proposed by [23]. For each experiment, 500 grams of Job's Tears grains were soaked in water at a ratio of cereal to water of 1:3 by weight for 6 to 7 hours. The subsequent steaming step was conducted at 100°C for 20 and 30 minutes, until the moisture content reached 35-40% (wet basis) [24]. After that time, the Job's Tears grains were heated using vacuum microwave heating at 80% degree of power and vacuum level at 600 mmHg [25] until they were dried for 12-14% moisture content (wet basis).

### 2.3 Degree of power conditions

Job's Tears grains from the previous experiment were used to investigate the vacuum microwave effect. Vacuum microwave (March Cool Industry Co., Ltd., Bangkok, Thailand, Thailand patent number 053870 model 2010), were performed at three levels of microwave power, namely, 60% (3,600 watts), 80% (4,800 watts) and 100% (6,000 watts), until the same final moisture content of the Job's Tears reached 12-14% (wet basis) was obtained.

### 2.4 Determination of physical properties and microstructure

#### *Percentage of water uptake and cooking time:*

The percentage of water uptake was measured with quick cooking Job's Tear by using the method of Gujral and Kumar [26]. In this method the boiling water was used to boil the grains with the ratio 20:1 by weight, then the grains are cooked - while recording the cooking time in min- drained for 5 minutes and then weighed the cooked grains. The percentage of water uptake is calculated as follows:

$$\text{percentage of water uptake} = \frac{\text{weight of cooked grains (g)} - \text{weight of uncooked grains (g)}}{\text{weight of uncooked grains (g)}} \times 100$$

In order to eliminate errors in the cooking times and so to have controlled optimum conditions

during the cooking of the Job's Tears, then fully cooked grains were combined. It was evaluated, not only using visual inspection (no hard and white color spot), but also using a texture analysis (Stable Micro System model TA XE plus) which measures the hardness value (256.97 ± 14.43 N).

**Color:** The color measurement was done by the CIELAB, using a Hunter Lab machine (Color Quest XE, U.S.A.). The CIE L\*, a\*, b\* were measured. The L\* value presents a measurement of the lightness of the material. The redness-to-greenness and the yellowness-to-blueness ranges are denoted by a\* and b\*, respectively.

**Microstructure:** SEMs of the grain samples were investigated by the Cam scan model MX-2000 (England). The samples were prepared by partially breaking the grain, using a mortar and a pestle, and then coating them with gold. The surface features of the starch granules were examined at 15 kV in three dimensions.

### 2.5 Statistical analysis

A completely randomized design was used. Differences between the mean values were established using Duncan's new multiple range tests at a confidence level of 95%. All experiments were performed in triplicates and analyses were performed using SPSS software.

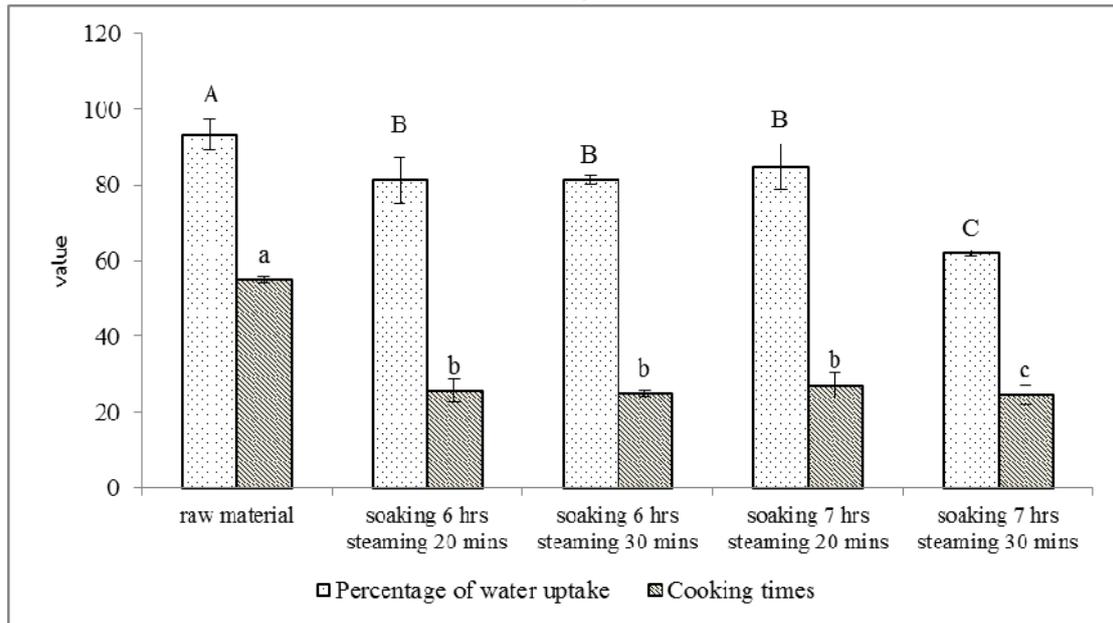
## 3. Results and discussion

### 3.1 Soaking and steaming

#### *Percentage of water uptake and cooking time :*

Figure 1 shows the percentage of water uptake and cooking time of Job's Tears after treatment at different soaking and steaming conditions. the percentage of water uptake and cooking time of grains after treatments is decreased significantly compared with the raw material. This is because of water absorption of the Job's Tears grain, leading to the partial gelatinization during the steaming process [27], as can be seen from Figure 6. The figure shows that the exteriors and interior of Job's Tears are gelatinized and have no porosity pattern when the steaming conditions are more intensive. The best conditions for this are a soaking time of 7 h and a steaming time of 30 min.

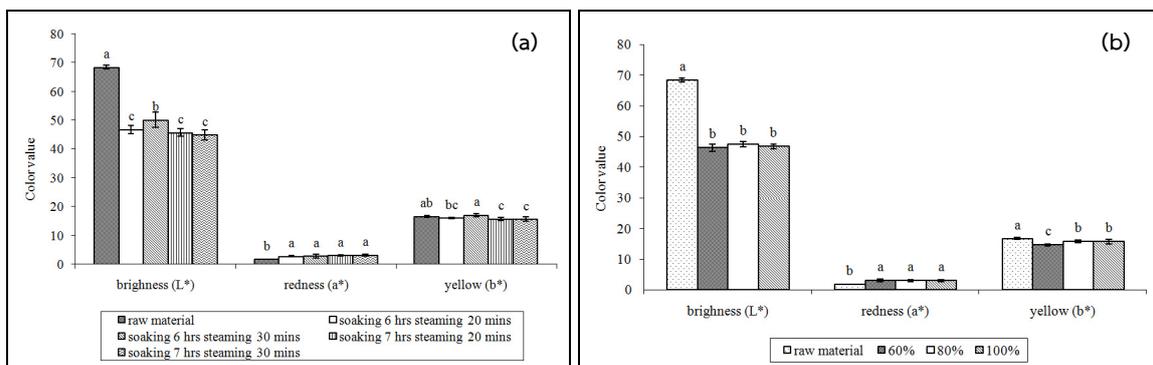
**Color:** The effects of soaking and steaming times on color is shown in Figures 2 and 3(a). The lightness of Job's Tears grains decreases with an increase of these times caused by the partial gelatinization and mainly induced by a Maillard browning reaction [13, 26]. The latter is a reaction of carbonyl and amino acid associated with heat, which leads to the brown pigments [28]. Our results are thus to be similar to those of Swasdesevi *et al.* [11] who argued that the lightness of rice decreases with an increase of the pre-steaming time, drying time and of the drying temperature.



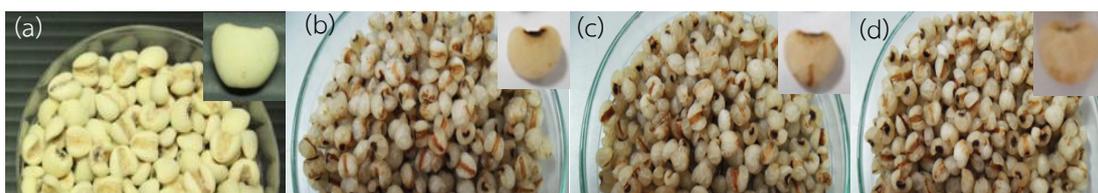
**Figure 1** Percentage of water uptake and cooking time (min) of Job's Tears for different soaking and steaming conditions. Superscripts <sup>(A,B,C)</sup> for percentage of water and <sup>(a,b,c)</sup> for cooking time mean that average values are significantly different at the 95% significance level



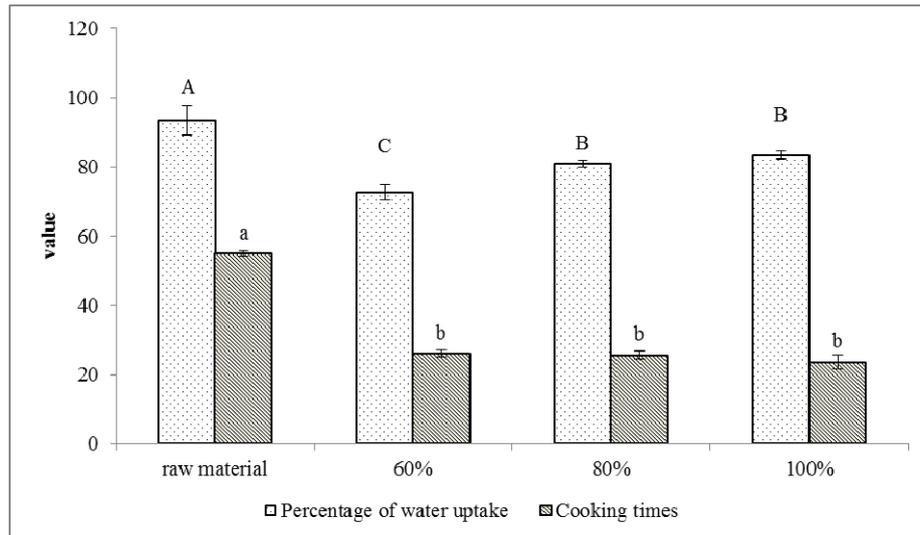
**Figure 2** Job's Tears obtained for different soaking and steaming conditions; (a) control, (b) soaking for 6 h, steaming for 20 min, (c) soaking for 6 h, steaming for 30 min, (d) soaking for 7 h, steaming for 20 min, (e) soaking for 7 h, steaming for 30 min



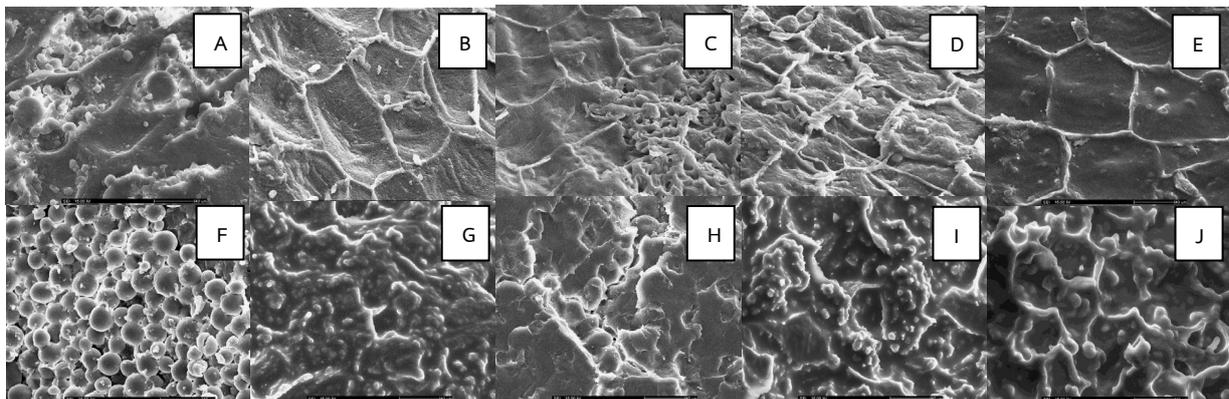
**Figure 3** Colors in CIELAB of Job's Tears at (a) different soaking and steaming conditions; (b) at different degrees of microwave power



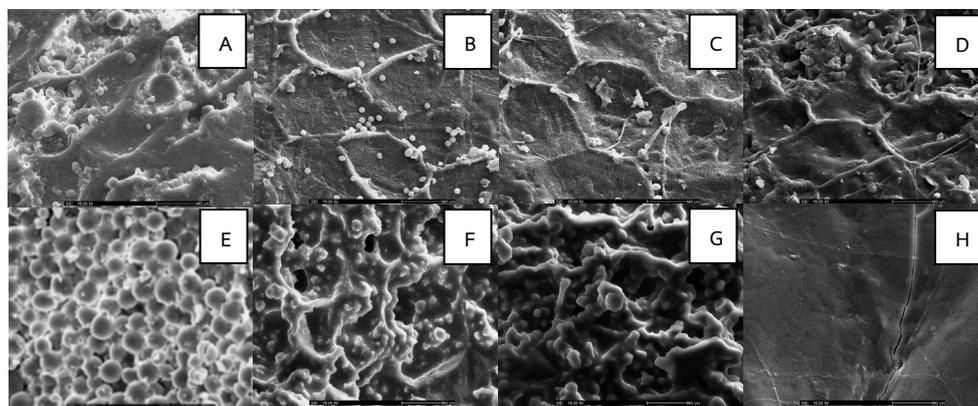
**Figure 4** Job's Tears grains obtained for different degrees of power. (a) control, (b) 60%, (c) 80%, (d) 100%



**Figure 5** Percentage of water uptake and cooking time (min) of Job's Tears at different degrees of power. The superscript <sup>(A,B,C)</sup> for percentage of water and <sup>(a,b,c)</sup> for cooking time mean the values were significantly different at 95%



**Figure 6** Scanning electron micrographs of Job's Tears after being treated by soaking and steaming (x 500). A-E represent exterior surface, F-J represent interior structure. A and F, raw material; B and G, soaking for 6 h and steaming for 20 mins; C and H, soaking for 6 h and steaming for 30 mins; D and I, soaking for 7 h and steaming for 20 mins; E and J, soaking for 7 h and steaming for 30 mins



**Figure 7** Scanning electron micrographs of Job's Tears after treatment with different degrees of power (x 500). A-D represent exterior surface, E-H represent interior structure. A and E, raw material; B and F, degree of power at 60%; C and G, power at 80%; D and H, power at 100%

**Microstructure:** The structures of Job's Tears are observed by SEM, and are shown in Figure 6. The figure discloses that the main structural composition of the raw material is starch granules. The soaking time has an effect, as it controls the seepage of water into the grain [27]. Also the starch granules decrease, as the steaming time increases (Figures 6G-6J). This is because the gelatinization happens during which time the starch granules have been heated with the excess water, leading to swelling of the granules, amylose diffuses out of the granules and gelatinization starts to occur [28].

### 3.2 Degree of microwave power

#### **Percentage of water uptake and cooking time:**

Figure 5 unveils that the percentage of water uptake decreases first for 60% power, when compared with raw material. This may be due to the gelatinization occurring during the steaming and drying process. However, when power is increased, the percentage of water uptake increases again. This tendency was also found by Figiel [19], who reported that increasing microwave power results in a change of the cellular structure and of the stimulated water absorption capacity. Our results are also in accordance with the obtained SEM images in Figures 7F-7H which show more fissures and porous structures within the grains. This phenomenon may contribute to an easier penetration of the excess water into the interior of the grains. On the other hand, the cooking times are not changed significantly when the microwave power is increased. This finding suggests that when increasing the power of drying, more fissures and porosity are formed within the Job's Tears grains. The water is, then, sufficiently absorbed into the Job's Tears' to induce the gelatinization. It can also be observed from the obtained experimental data and the corresponding SEM images, that the starch granules disappear when the percentage of water uptake reaches 70% and the microwave power exceeds 60% (Figures 5 and 7).

**Color:** The effects of the degree of microwave power on color is shown in Figures 3(b) and 4. The lightness of Job's Tears grains decreases relative to the raw material. This change may be caused by the Maillard browning reaction and the heating during the drying step [11]. On the other hand, the increase of the microwave power exhibits no significant change of the color, a result which is not consistent with findings from previous studies [11, 19, 29] reporting that fruit and vegetable color changes to charring when the microwave power heating is increased too intensively.

**Microstructure:** The effects of the degree of microwave power on the morphology of grain are shown in the SEM images of Figure 7. It can be noticed that fissures and porous structures form within the Job's Tears grains with increasing microwave power. The most fissured structure in the interior area occurs at the maximum microwave power of 100%. Consequently, this may have been caused by the increased microwave power during the drying step

which increases the drying rate, causing rapid rise of the product temperatures and, subsequently, accelerates the rate of water removal which, eventually, induce the cracks and fissures in the inner grains [30].

### 4. Conclusions

The soaking and steaming processes significantly affect the qualities of Job's Tears in terms of percentage of water uptake, cooking time, color and grain microstructure. Both the percentage of water uptake and the cooking time decrease with an increase of soaking and steaming times, whereas the color of the treated Job's Tears remains dull. An increase of the degree of microwave power affects the percentage of water uptake and the Job's Tears cell structure as shown by SEM, but does not, on the other hand, influence the product's cooking time or its color. The optimal treatment for a quick cooking of Job's Tears is soaking at an ambient temperature for about 7 h, then steaming for about 30 minutes. Finally, the product is dried with a vacuum microwave at 80% power, until it reaches a final moisture content of 12-14%. The methodology is able to provide a good quick cooking product periods. With these suitably identified processing parameters, not only will Job's Tears consumption be more convenient and so expected to increase its use, but it could also be useful for SMEs traders to market more of this nutritive cereal.

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