

# Application of Mulberry (*Morus alba L.*) for Supplementing Antioxidant Activity in Extruded Thai Rice Snack

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## ABSTRACT

Owing to creation of Thai rice snack with health benefits for higher potential in commercial scale, mulberry leaf was applied in the production of extruded snack product. Mulberry leaf in dried powder form was mixed with rice, corn, soy, sugar, oil, vitamins and minerals to investigate the operating conditions with twin-screw extruder at varying mulberry powder content (5, 7.5 and 10%), screw speed (300 and 350 rpm) and feed moisture (13, 15 and 17%) in the  $3 \times 2 \times 3$  factorial experiment. The extrudates were examined of functional properties (antioxidant activity and phenolic compounds) and some physical characteristics (expansion ratio, bulk density, texture measurement and organoleptic test). The results had shown that at higher mulberry content (10%), the product was difficult to operate, unsmooth shape and less expand. While lower screw speed (300 rpm) and moderate moisture content (15%) gave suitable expansion and bulk density with better preference in appearance. This product still has antioxidant activity and phenolic compounds which corresponded to the optimum operating condition (5% mulberry content, 300 rpm and 15% feed moisture) from the statistical analysis. Finally, the finished product was evaluated in the pattern of nutrition labeling, microbiological test and packed in metallize bag to examine for moisture content,  $a_w$ , colour, TBA number, antioxidant activity and sensory test during storage time (0-4 months) at room temperature.

**Key words:** mulberry, extruded snack, antioxidant activity, phenolic compounds

## INTRODUCTION

Consumer today are demanding ever - broadening selections of a variety of snack foods. Extrusion process has provided a means of manufacturing new and novel products and has revolutionized many conventional snack manufacturing process. Extrusion equipment offers many basic design advantages that result in minimizing time, energy and cost while at the same time increasing the degree of versatility and

flexibility that was not previously available by other means (Harper, 1981; Riaz, 2000). Consequently, the use of cooker extruder has been expanding rapidly in the snack food industry and one of the majority of extruded snacks on the market fall into the category of direct expanded snack. Due to variations in processing conditions affect process variables as well as product quality (Mercier *et al.*, 1989; Young *et al.*, 2005.) extruded product quality can vary considerably depending on the extruder type, screw configuration, feed

moisture, temperature profile in the barrel, screw speed, feed rate and die profile (Chung, 2000; Liu *et al.*, 2000; Mendonca *et al.*, 2000; Gujral and Singh, 2002; Lin *et al.*, 2002; Ding *et al.*, 2006).

Natural plants have received much attention as source of biologically active substances including antioxidants, antimutagens and anticarcinogens. Reports indicate that mulberry (*Morus Alba L.*) especially mulberry leaves are palatable, non – toxic and nutritious which contain protein, carbohydrate, calcium, iron, ascorbic acid,  $\beta$ -carotene, vitamin B-1, folic acid and vitamin D (Bose, 1989). Among the various nutritional components, flavonoids and moracins are known to have effects as antioxidants or free radical scavengers (Kim *et al.*, 1999; Sharma *et al.*, 2001). Recent studies have indicated that dietary mulberry showed hypoglycemic (Park *et al.*, 2005) and hypolipidemic (El-Beshbishy *et al.*, 2006) effects in certain animal models. In addition, mulberry leaf extracts which contain rutin, quercetin, isoquercetin and other flavonoids have been shown to inhibit oxidative modification of LDL and may reduce arteriosclerosis (Zhishen *et al.*, 1999; Katsube *et al.*, 2006).

Development in the snack food industry are numerous and ever – changing. One of the general idea of the recent extruded snack trends in the industry is the new health benefits for extruded snack foods. Basically, the combination of ingredients using for snack food production contain relatively high levels of starch to maximize the expansion of final product. Furthermore, rice is one of the most important agricultural products in Thailand which is well suited and using as the main raw materials for developing extruded snack because of their high starch content and excellent expansion properties (Ryu, 2004). Accordingly, the aim of this study was to develop new concepts of snack food for supplementing antioxidant activity by adding mulberry leaves with rice flour in extrusion process, which has not been investigate previously.

## MATERIALS AND METHODS

### Preparation of dried mulberry powders

Mulberry leaves had been prepared to be dried mulberry powder form before mixing with other raw materials in the snack food production as shown in Figure 1.

### Extrusion process for snack production

Dried mulberry powders were mixed with raw ingredients for snack production by extrusion process as shown in Figure 2.

### Experimental design

To study the optimum operating conditions of snack production, the  $3 \times 2 \times 3$  in factorial experimental design was employed to show the effect of mulberry content (5, 7.5 and 10%), screw speed (300 and 350 rpm) and feed moisture (13, 15 and 17%) on the extrudate. The chemical and physical properties of extrudates were examined such as antioxidant activity (Ohnishi *et al.*, 1994), total phenolic compound (Singleton and Rossi, 1965), expansion ratio (Halek and Chang, 1992), bulk density (Rahman, 1995), texture measurement by TA-XT2i texture analyzer, colour measurement by Datacolor, including organoleptic properties. Data obtained were analyzed by STATISTICA software and determined the optimum operating conditions by computer programme.

### Sensory evaluation, microbiological test, nutritional evaluation, production cost and physicochemical changes during storage time

The direct expansion extruded snack at the optimum operating condition was produced and flavored with oil and seasoning. The finished product was tested for sensory evaluation, microbiological test, nutritional evaluation for antioxidant property and the pattern of “Nutrition Facts”, including calculated the production cost for further commercial production.

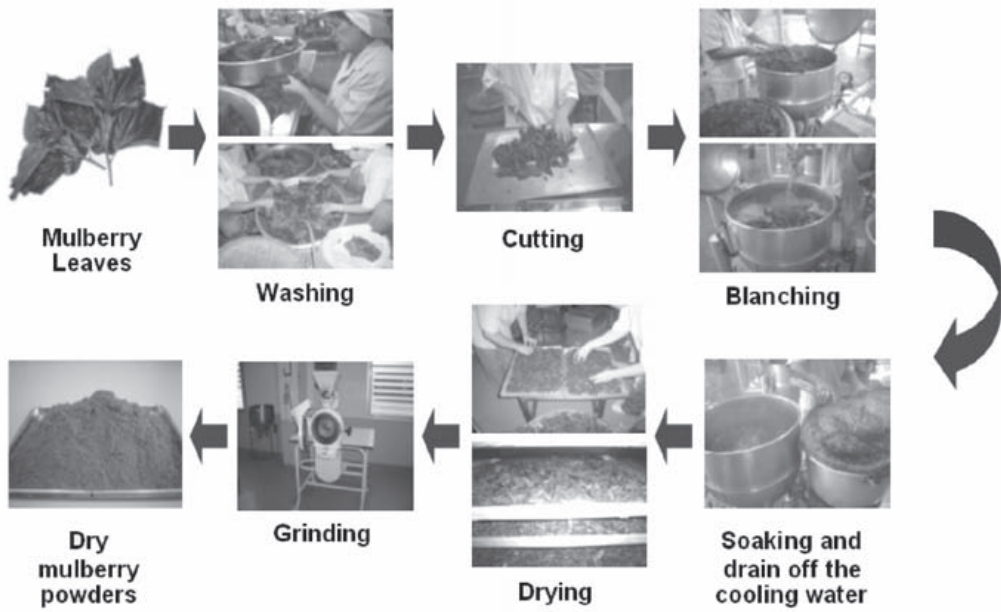


Figure 1 Flow chart of preparation for dried mulberry powders.

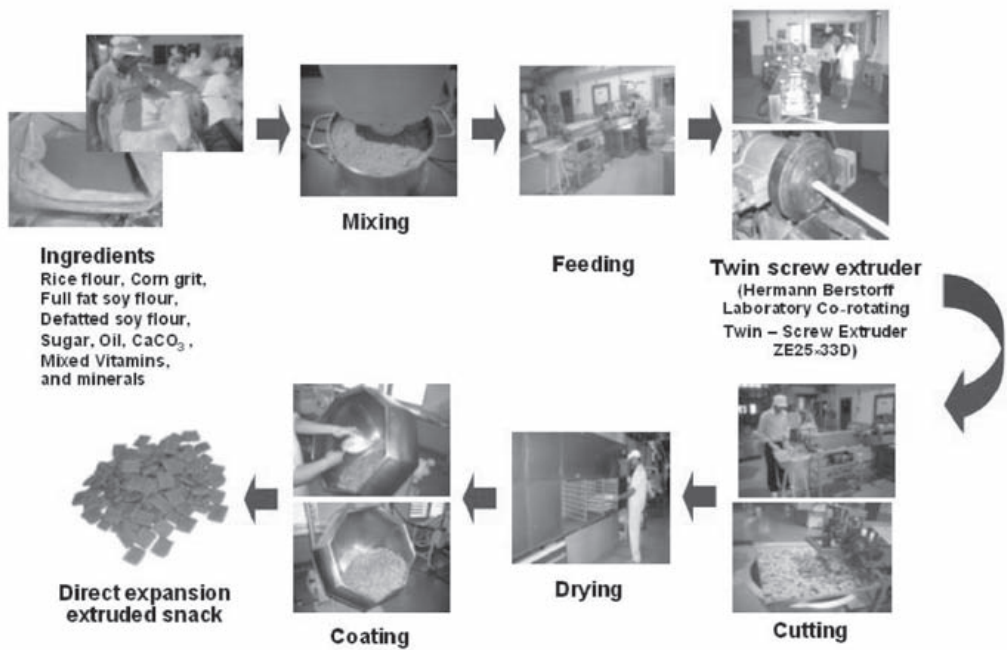


Figure 2 Processing line of snack food production.

Moreover, the finished product was packed in metallize bags and kept at room temperature for 4 months, then testing for physicochemical changes of product such as moisture,  $a_w$ , color, hardness, TBA numbers, antioxidant activity, total phenolic compounds and sensory test during storage times.

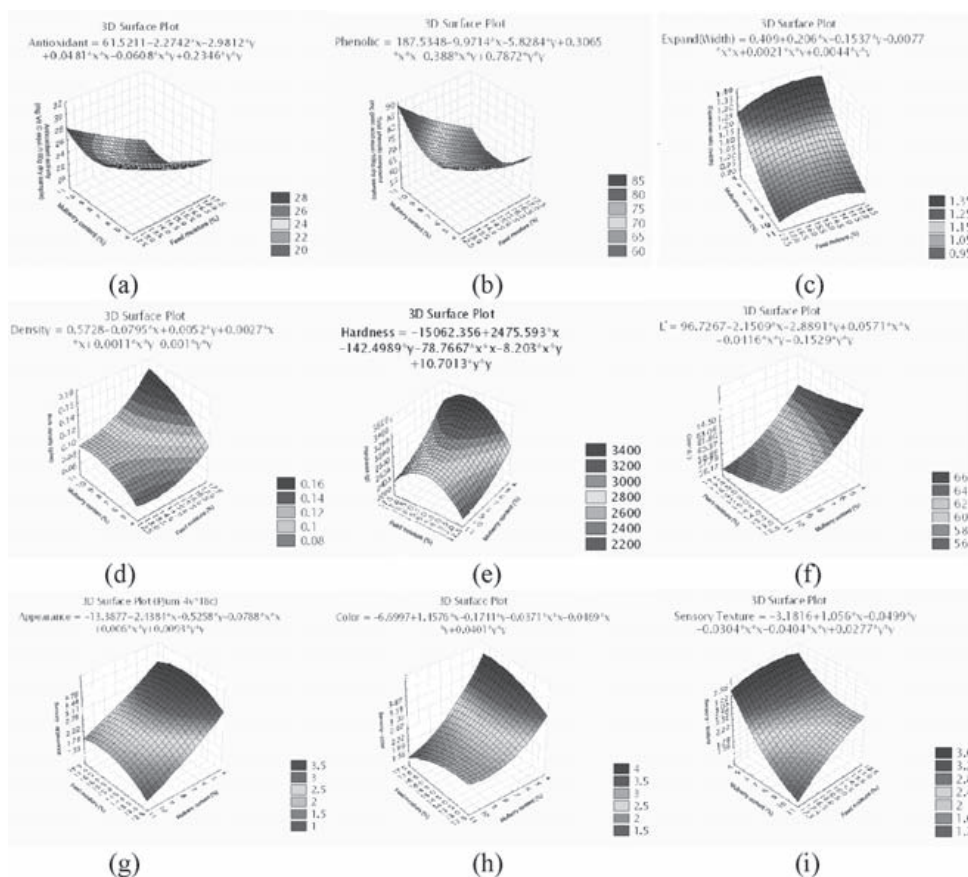
## RESULTS AND DISCUSSION

### Effect of the operating conditions on the chemical and physical properties of extrudate

The results showed that the operating conditions varying at mulberry content (5, 7.5 and 10%), screw speed (300 and 350 rpm) and feed

moisture (13, 15 and 17%) affected on the chemical and physical properties of extrudates as example of surface plot shown in Figure 3.

• **Antioxidant activity and total phenolic compounds** : It was found that mulberry content, screw speed, feed moisture and the interactions between these variables had significant effect on antioxidant activity and total phenolic compounds. As a result of temperature is the major factor influencing in antioxidant and polyphenols (Larson, 1988), higher screw speed and feed moisture reduced antioxidant activity and total phenolic compounds. Because of higher screw speed produced high shear to get high



**Figure 3** Effect of operating conditions (mulberry content VS. feed moisture) on the properties of extrudates : (a) antioxidant activity; (b) total phenolic compounds; (c) expansion ratio; (d) bulk density; (e) hardness; (f) color ( $L^*$ ); (g) sensory-appearance; (h) sensory-color; (i) sensory-texture.

temperature during the production. Similarly higher feed moisture increased residence time to get more heat for cooking the product (Miller, 2004).

- **Expansion ratio and bulk density :**

It was found that both of variables, mulberry content and feed moisture had significant effect on expansion ratio and bulk density. For higher mulberry content which containing more fiber decreased expansion ratio and increased bulk density of the product. Since fiber does have significant effect on product structure and texture, it does not expand but acts as a solid filler diluting the expanding starch ingredient in the mix. The product thus increase with increasing fiber content (Ryu, 2004). Furthermore, higher feed moisture decreased expansion ratio and increased bulk density also. At higher moisture content, the specific mechanical energy input decrease resulting in a lower motor torque, a lower product temperature and die pressure (Ryu, 2004). Hence, these conditions generated lower steam which occurred less puffing.

- **Hardness :** It was found that feed moisture had significant effect on texture or hardness of product. Generally, the die pressure decreases with increasing moisture content (Ryu, 2004) which tends to receive the product more dense structure and hardener.

- **Color (L\*) :** It was found that mulberry content, screw speed, feed moisture and the interaction of these variables had significant effect on the color or lightness of product. At higher mulberry content, the product will have deep green color to get slight lightness (L\*). Similarly, at higher feed moisture makes the product more dense, deep green color and lower lightness.

- **Sensory evaluation :** It was found that mulberry content had significant effect on all the characteristics of product in appearance, color, flavor and texture, whereas feed moisture had only significant effect on appearance and

texture. However, the operating conditions at 5% mulberry content, 300 rpm screw speed and 15% feed moisture had higher preference in appearance, color, flavor and texture than other conditions.

### **The optimum operating conditions of snack production**

Due to the antioxidant property (antioxidant activity and total phenolic compounds) which is the key factor of benefit health for snack food and the preference in organoleptic test which related to requirements of consumer in physical properties of finished product, the optimum operating conditions had been analyzed from these obtained data by computer programme. It was suggested that the optimum operating conditions should be operated at 5% mulberry content, 300 rpm screw speed and 15% feed moisture.

### **Sensory evaluation, microbiological test, nutritional evaluation and production cost**

The finished product had been tested for sensory evaluation, microbiological test, nutrition evaluation and production cost respectively. The results had shown that the product was acceptable and safety from microbiological number (total plate count, coliform bacteria, yeast and mold). For nutrition evaluation the finished product still had antioxidant activity (45.51 mg vitC equi. per 100 g dry sample) and total phenolic compounds (77.79mg gallic acid equi.per 100g dry sample), including good consuming behavior in the pattern of nutrition labeling as shown in Table 1. For further commercially production, this product had potential and possible for investment in the snack food industry as the production cost shown in table 2.

### **Physicochemical changes of finished products during storage time**

The results of physicochemical changes

**Table 1** Nutritional evaluation in the pattern of “Nutrition Facts”.

<b>Nutrition Facts</b>	
Serving Size : 1 package ( 30 g.)	
Servings Per Container 1	
<b>Amount Per Serving</b>	
<b>Calories</b> 130 kcal	Calories from Fat 35 kcal
<b>% Daily Value *</b>	
<b>Total Fat</b> 3.5 g	5 %
Saturated Fat 0 g	0 %
<b>Cholesterol</b> 0 mg	0 %
<b>Sodium</b> 180 mg	
<b>Total Carbohydrate</b> 20 g	7 %
Dietary Fiber 3 g	12 %
Sugars 3 g	8 %
<b>Protein</b> 4 g	
Percent Thai RDI*	
Vitamin A 20 %	•
Vitamin B1 8 %	•
Vitamin B2 8 %	•
Calcium 20 %	•
Iron 4 %	•
* Percent Thai Recommended Daily Intakes for population over 6 year of age are based on a 2,000 calorie diet.	
Energy needs vary by individuals. If your activities require energy of 2,000 kcal per day, your daily diet should provide the following nutrients.	
Total Fat	Less than 65 g
Sat Fat	Less than 20 g
Cholesterol	Less than 300 mg
Total Carbohydrate	300 g
Dietary Fiber	25 g
Sodium	Less than 2,400 mg
Calories per gram :	
Fat 9 • Carbohydrate 4 • Protein 4	

**Table 2** The production cost of snack food product.

Cost	Baht / kg
Raw materials before extruding	26.85
Plain snack after extruding, yield 90%	29.83
Plain snack + Operating cost	29.83 + 18 => 47.83
Flavoring slurry	27.80
Flavored snack	75.63
Cost	Baht / 30g
Flavored snack	2.27
Metallize bag	1.20
Labor cost for packing	0.30
Total cost for production of flavored snack per one serving	3.77

during storage time were found that this product was kept good performance and suitable for packing in metallize bag which stored at room temperature more than four months as shown in Figure 4.

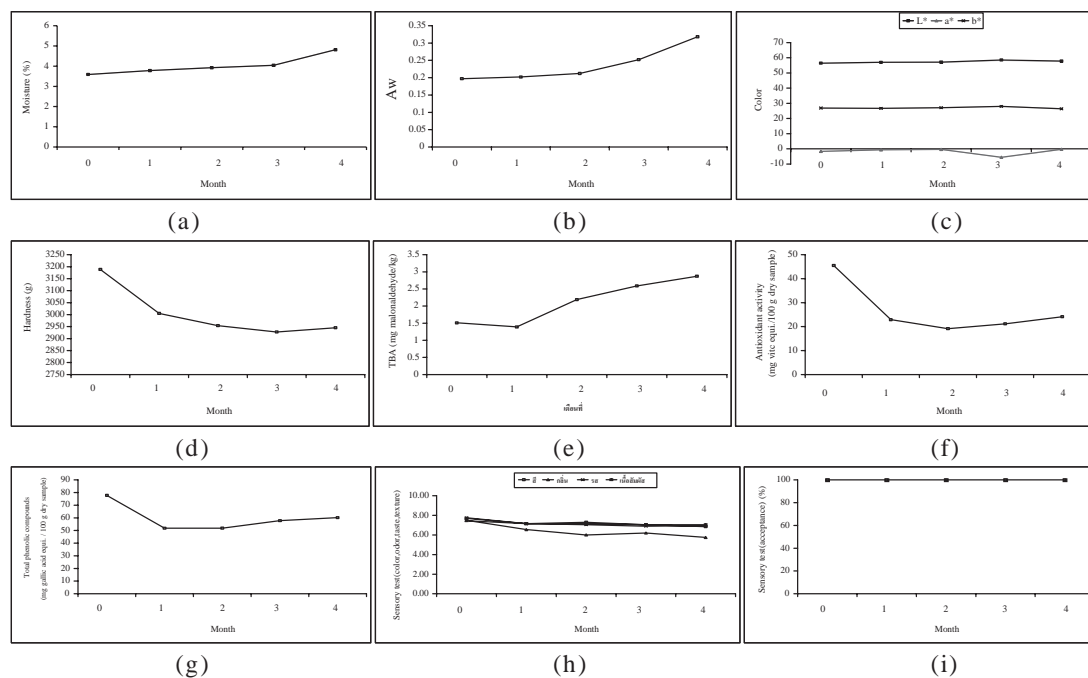
## CONCLUSION

For developing direct expansion extruded snack by using rice as basic raw material and supplementing antioxidant property from mulberry leaves in the production, the optimum conditions of extrusion process should be operated at 5% mulberry content, 300 rpm screw speed and 15% feed moisture. The product has been acceptable and safety from biological hazard. In addition, this product enhances good consuming behavior according to the recommended daily allowances, especially new health benefits from mulberry such as antioxidant

activity, total phenolic compounds and dietary fiber. This research is beneficial for transfer technology to food manufacturer and possible for commercial production. However, for further research, it may be better if we can use mulberry leaf extracts free from chemical residue and low production cost for drying extracts powder replace to dry mulberry leaf powder because of the limitation of high fiber against expansion of snack product.

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**Figure 4** The results of physicochemical changes during storage time : (a) moisture; (b)  $a_w$ ; (c) color; (d) hardness; (e) TBA numbers; (f) antioxidant activity; (g) total phenolic compounds; (h) sensory test (color, odor, taste, texture); (i) sensory test (acceptance).

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