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Influence of dry- and wet-milling processes on physicochemical properties, syneresis, pasting profile and microbial count of job's tear flour

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Abstract

The study aimed to examine the impact of different milling processes (i.e. dry- and wet-milling processes) on various qualities of job's tear (*Coix lacryma-jobi*) flour. No remarkable differences of the chemical composition and swelling value between dry- and wet-milled job's tear flours were observed ($p > 0.05$), whereas the solubility values of wet-milled job's tear flour were remarkably higher compared to that of dry-milled flour. On the contrary, the syneresis value of wet-milled job's tear flour was significantly lower than that of dry-milled flour, pointing to the freeze-thaw stability of the flour gel. Moreover, the viscosity of wet-milled job's tear flour showed significant values, suggesting the milling process influences pasting and viscosity properties of job's tear flour. Low bacterial and fungal counts were also found in both job's tear flours. Therefore, job's tear flour prepared by wet-milling process might be applied in food products. It is due to high values of nutrients, solubility, freeze-thaw stability and viscosity.

Introduction

Cereal grains are good sources of food carbohydrate. Cereals additionally provide a variety of chemical composition such as carbohydrate, amino acids, vitamins and minerals, as well as many non-nutritive substances. Recently, considerable attention to cereals and related products for health benefit has been focused by consumers and researchers. Job's tear or adlay (*Coix lacryma-jobi*) is a commercial cereal crop which is extensively cultivated and consumed in Asia such as China, Indonesia, Thailand, Burma and Philippines. Job's tear predominantly contains carbohydrate (65%) and also consists of protein (15%), moisture (11%) and fat (6%) with trace minerals and vitamins such as calcium, phosphorus, niacin, thiamine and riboflavin (Duke, 1983; Yang *et al*., 2004). In Asian countries, job's tear can be made into several kinds of food like sweet dishes, beverages and soups (Yang *et al*., 2004). Besides that, it can also be used as a medicine functional food due to its beneficial effect to human such as antiproliferative and chemopreventive effects on lung cancer (Chang *et al*., 2003), and metabolism improvement of gastrointestinal tracts (Chiang *et al*., 2000).

In general, cereals can be prepared as flour by wet- and dry-milling processes. The milling processes can make the differences to the physical and chemical properties of flour (Chen *et al*., 1999; Chiang and Yeh, 2002; Yoenyongbuddhagal and Noomhorm, 2002). The wet-milling process, however, consumes a large amount of water which generates a wastewater problem (Yeh, 2004). Moreover, flour can be used to produce various starch-based frozen food products. These products probably show syneresis attribute after thawing. It is due to textural changes related to starch retrogradation (Jacobson and BeMiller, 1998; Varavinit *et al*., 2000), making products unacceptable to consumers. During thawing, water attached in frozen food can be separated from the food matrix and also causes a change in the texture, drip loss and deterioration in overall quality of the products. Therefore, acceptable flour should have a high viscosity and undergo low syneresis attribute (Rahman, 1999).

In addition, the data related to characteristics of job's tear flour particularly the effect of milling process (i.e. dry- and wet-milled processes) on the properties of job's tear flours, are very limited. Thus, the objective of this research was to investigate the chemical, physical and microbial properties, as well as pasting and syneresis properties of dry- and wet-milled job's tear flours. This research would make a contribution toward the improvement in the quality of job's tear flour and toward the possibilities to develop the job's tear flour-based frozen products.

Materials and Methods

Processing of job's tear flour

Job's tear (*Coix lacryma-jobi*) was prepared using two different milling processes; dry- and wet-milling processes, as shown in Figure 1. To produce dry-milled job's tear flour, job's tear was milled by a

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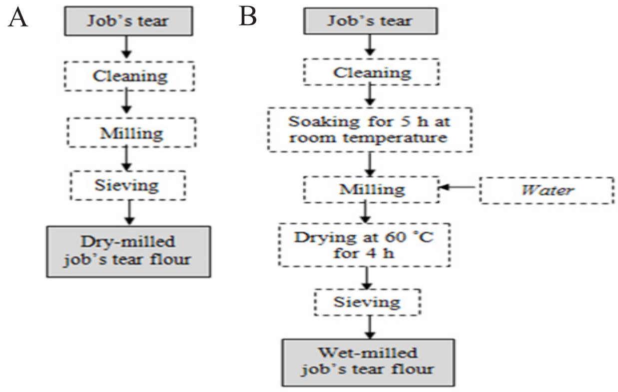

Figure 1. Production of job's tear flour from (A) dry-milling process and (B) wet-milling process

hammer mill after cleaning. On the other hand, wet-milled job's tear flour was produced as follows; job's tear was soaked in water for 5 h at room temperature, drained and mixed with water (3:1, w/w), milled by a blender, squeezed using a cotton sheet, and dried at 60°C for 4 h in a hot air oven. Subsequently, both dry- and wet-milled job's tear flours were sieved to obtain homogeneous product and storage at 4°C in a sealed-plastic bag for further analysis.

Determination of physicochemical properties

A whole set of chemical properties, i.e. a_w, pH, moisture content, protein, fat, fiber, ash and carbohydrate, of job's tear flour was examined according to standard methods, as described by AOAC (1995). Besides these chemical properties, the Hunter color parameters (L^*, a^* and b^* values) of the flour sample were measured by a spectrophotometer colorimeter. The water solubility and swelling values of the flour sample were also determined as follows: one gram of the sample was put in a centrifuge tube, and 10 ml of distilled water was added and homogeneously mixed. Afterwards, the flour solution was incubated in a water bath at 37°C for 30 min and centrifuged at 3000 g for 10 min. The swelling value can be computed by the weight of pellet to original sample and expressed as g gel per g sample (g gel/g, wet basis). On the other hand, the supernatant phase was dried at 105°C for 3 h to obtain the residue fraction. The water solubility was estimated as percentage by the weight of the residue to the original. It indicates total soluble solid in flour solution. All measurements were performed in triplicate.

Determination of microbiological properties

The total plate, and yeast and mold counts were obtained using the pour plate technique on plate count agar, which is a standard method (AOAC, 1995). Duplicate was done for each dilution. The number of microbial was expressed in colony forming unit per g sample (CFU/g).

Determination of syneresis property

The syneresis of the flour sample was monitored by freeze-thaw stability method (modified from Charoenrein *et al*., 2011). The heated flour gel (5% flour in water, w/w) was frozen at -18°C for 24 h and then thawed at three conditions (30, 60 and 90°C) for 30 min. The sample was re-frozen and re-thawed for up to 5 cycles each condition. After thawing, the thawed sample was centrifuged and the liquid which had separated from the sample was weighted. The percentage of syneresis of the sample was calculated as the ratio of the weight of liquid separated from the sample to the total weight of the sample before centrifugation and then multiplied by 100. The data were reported as the average of three measurements for each aforementioned condition.

Determination of pasting properties

Pasting properties of job's tear flour were determined using a brabender viscoamylograph. The slurry was pre-heated to 50°C, heated up to 95°C at a constant rate and then held at 95°C for 18 min. It was subsequently cooled to 55°C and then held at 55°C for 18 min. During pasting measurement, viscosity values at beginning of gelatinization, peak viscosity, start of holding period, start of cooling period, end of cooling period, and end of final holding period of job's tear flour sample were recorded. In addition, the viscosity values of breakdown (peak viscosity minus viscosity at start of cooling period) and setback (viscosity at end of cooling period minus at start of cooling period) were calculated. The data were reported as the average of triplicate measurements.

Statistical analysis

In the study, completely randomized design (CRD) was used to design the experiment. The data obtained from three replications were analyzed and shown as means + standard deviation (SD). A two-sample t-test analysis was conducted to differentiate between means of the two types of job's tear flour at the 0.05 confidence level using SPSS for Windows program.

Results and discussions

Effect of milling process on characteristics of job's tear flour

The physicochemical and microbiological properties of job's tear flour from dry and wet milling processes were studied and the result is shown in Table 1. The color of dry-milled job's tear flour showed slightly darker than the wet-milled flour, according

Table 1. Characteristics of dry- and wet-milled job's tear flours

Characteristics	Dry-milled job's tear flour	Wet-milled job's tear flour
Physical properties		
Color parameter		
L*	85.90 ± 0.47[a]	87.85 ± 0.44[b]
a*	0.71 ± 0.03[a]	0.46 ± 0.02[b]
b*	9.29 ± 0.10[a]	7.34 ± 0.21[b]
Solubility (%)	3.30 ± 0.09[a]	5.29 ± 0.23[b]
Swelling (g gel/g)	4.63 ± 0.34[a]	4.72 ± 0.17[a]
Chemical properties		
a_w	0.59 ± 0.01[a]	0.63 ± 0.00[b]
pH	7.19 ± 0.02[a]	7.03 ± 0.01[a]
Moisture (%)	10.42 ± 0.08[a]	11.41 ± 0.27[b]
Protein (%)	1.29 ± 0.01[a]	2.57 ± 0.01[b]
Fat (%)	7.80 ± 0.14[a]	4.71 ± 0.08[b]
Fiber (%)	0.95 ± 0.11[a]	0.65 ± 0.17[b]
Ash (%)	0.84 ± 0.12[a]	0.82 ± 0.05[a]
Carbohydrate (%)	78.70 ± 0.18[a]	79.94 ± 0.16[a]
Microbiological properties (CFU/g)		
Total plate count	5x10³ [a]	2x10⁴ [b]
Yeats and mold	< 10[a]	< 10[a]

The superscripts with the different letters within the same row are significantly different (p < 0.05).

Table 2. Freeze-thaw stability of dry- and wet-milled job's tear flours at different thawing temperatures

Cycle	30 °C		60 °C		90 °C	
	Dry-milled	Wet-milled	Dry-milled	Wet-milled	Dry-milled	Wet-milled
1	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
2	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
3	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
4	8.18 ± 3.47[a]	1.86 ± 1.35[b]	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
5	11.29± 0.42[a*]	8.96 ± 2.81[b*]	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00

The superscripts with the different letters within the same thawing temperature and cycle of dry-milled and wet-milled job's tear flours are significantly different (p < 0.05).

to all Hunter color parameters (L^*, a^* and b^* values). The solubility value of wet-milled job's tear flour was significantly higher than that of the dry-milled flour (5.29% compared to 3.30%). A possible explanation is that it is due to the different of milling process. As the wet-milling process uses water in the milling step, it results in high ability of solubility of wet-milled flour. The results are in good agreement with the results found in rice flour that solubility of wet-milled rice flour also shows higher value compared to dry-milled rice flour (Srirod and Piyajomkhawn, 2003). No significant differences between swelling values (4.63-4.72 g gel/g) of two types of job's tear flour were found ($p > 0.05$), however the swelling value of wet-milled job's tear flour was slightly higher than that of the dry-milled flour. It is because the wet-milled flour can absorb water more than the dry-milled flour due to the milling processing.

In the case of chemical composition of both job's tear flours (Table 1), no significant differences between pH value, ash and carbohydrate contents of dry- and wet-milled job's tear flours were observed ($p > 0.05$), whilst a_w value, moisture and protein contents of wet-milled job's tear flour were slightly higher compared to that of dry-milled flour. On the contrary, the contents of fat and fiber of dry-milled job's tear flour showed considerably higher than that of wet-milled flour. The chemical composition of the studied job's tear flour is comparable amounts with the results found by Pornkitprasarn (1987).

Table 1, microbial count of wet-milled job's tear flour was higher than that of dry-milled job's tear flour ($2x10^4$ CFU/g compared to $5x10^3$ CFU/g), suggesting due to water contamination during wet-milling process and higher moisture content of the flour (11.41% vs. 10.42%). The wet-milling process also takes longer than the dry-milling process, probably resulting in higher contamination. However, yeasts and molds of both dry- and wet-milled job's tear flours were comparable amounts (less than 10 CFU/g). According to the finding results, it can be claimed that the milling process has significant effects on the physicochemical and microbiological properties of job's tear flour.

Effect of milling process on syneresis attribute of job's tear flour

In the study, job's tear flour was subjected to the determination of freeze-thaw stability at various thawing temperatures (30, 60 and 90°C) for 5 cycles. Table 2 illustrates the data expressing as percentage of syneresis. From the first to third freeze-thaw cycles at 30°C, the syneresis behavior of both wet-milled and dry-milled job's tear flours was not observed (0.00%). It is suggested that both job's tear flours can absorb water within their gel-network structure. After the third freeze-thaw cycle, the result showed an obvious increase in the syneresis value of both job's tear flours, particularly of dry-milled job's tear flour. Freeze-thawed gels of dry-milled job's tear flour had significantly higher syneresis values compared to wet-milled flour gels ($p < 0.05$) and the syneresis value was even more pronounced through subsequent freeze-thaw cycles. Table 2, the syneresis values of dry-milled and wet-milled job's tear flours at the fourth cycle are 8.18 and 1.86%, respectively. However, these values are remarkably lower than that of the freeze-thawed gels at the fifth cycle (11.29% for dry-milled job's tear flour and 8.96% for wet-milled job's tear flour). This result implies that milling process plays an important role in the retrogradation associated with freezing and thawing of job's tear flour. It can also be concluded that wet-milled job's tear flour had significantly less syneresis than that of the dry-milled flour. Therefore, wet-milled job's tear flour is suggested for frozen food applications due to its high freeze-thaw stability.

At 60 and 90°C from the first to fifth freeze–thaw cycles, both wet-milled and dry-milled job's tear flours did not show syneresis behavior (0.00%). The gelatinization of the flour gel has significant effects on water absorption and swelling of the gel. As job's tear flour contains large amount of starch and amylose (56.68% and 10.85%, respectively) (Pornkitprasarn, 1987), amylose molecules in the flour gel are released when heating up and they can

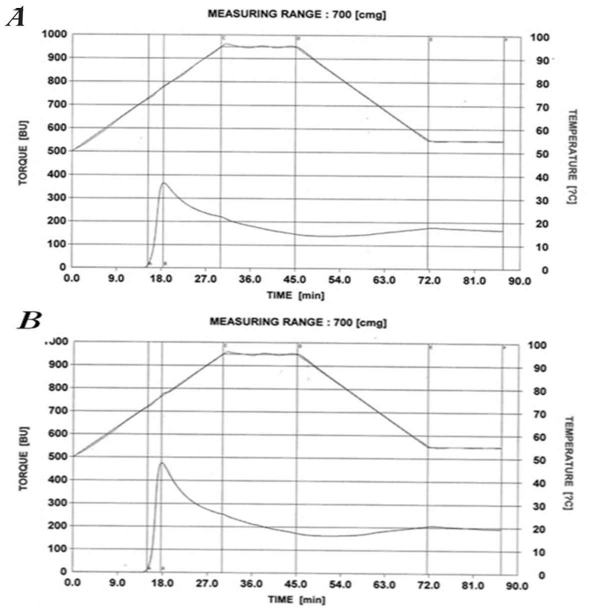

Figure 2. Pasting profile of (A) dry-milled job's tear flour and (B) wet-milled job's tear flour using brabender viscoamylograph

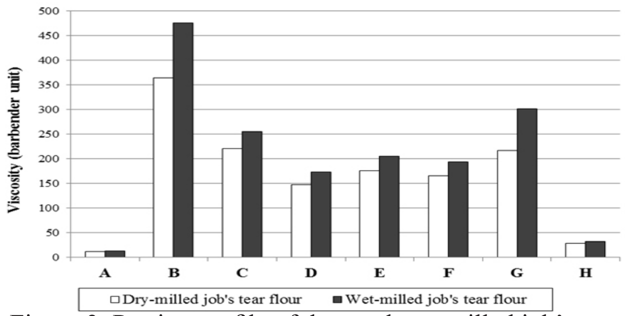

Figure 3. Pasting profile of dry- and wet-milled job's tear flours; A, beginning of gelatinization; B, peak viscosity; C, start of holding period; D, start of cooling period; E, end of cooling period; F, end of final holding period; G, breakdown; H, setback

rearrange to make a strong gel network, which can attach water in the network, when cooling down (Srirod and Piyajomkhawn, 2003).

Effect of milling process on pasting properties of job's tear flour

The pasting properties of job's tear flour as affected by milling processes were determined by a brabender viscoamylograph. Pasting curves and temperature profile of dry-milled and wet-milled job's tear flours obtained from brabender viscoamylograph are shown in Figure 2. It is clearly observed that viscosity profile of wet-milled job's tear flour is higher than that of dry-milled job's tear flour, especially the peak viscosity.

The viscosity values of job's tear flours as a function of heating and cooling are described in Figure 3. In the pasting measurement, higher values for peak viscosity and breakdown were clearly observed in wet-milled job's tear flour compared to dry-milled job's tear flour (476 vs. 365 brabender unit and 302 vs. 217 brabender unit, respectively), whereas comparable values for setback were shown in both job's tear flours (28-32 brabender unit). The higher values of viscosity profile were also investigated in wet-milled job's tear flour during gelatinization.

According to the results, it is suggested that the solubility and swelling effects might be responsible for the viscosity values of job's tear flour. Also, it implies that dry-milled flour probably have a lower degree of recrystallization of gelatinized starch during cooling. It is because the milling process affects pasting properties by the mechanical damage of starch granules (Suksomboon and Naivikul, 2006).

Conclusion

Dry- and wet-milled job's tear flours had marked differences in solubility value, pasting profiles and syneresis attribute, whilst slightly differences in chemical composition of both job's tear flours were observed. Higher solubility and viscosity values of wet-milled job's tear flour indicated higher stability during freezing and thawing of the flour gel compared to dry-milled job's tear flour. Therefore, it can be recommended that wet-milled job's tear flour would be very interesting for frozen food applications due to its acceptable properties.

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