Preliminary Study of Hanjeli (Coix lacryma-jobi L) Flour for Food Uses

E Mulyono1*, A Kusuma2, K T Dewandari1, S Darniadi1
1Indonesian Center for Agricultural Postharvest Research and Development
Jl. Tentara Pelajar No 12, Cimanggu Bogor
2Department of Chemistry Science, Pakuan University, Bogor
*Email : edy.mulyono2012@gmail.com

Abstract. Job’s tears (Coix lacryma-jobi L) is one of staple crop has a potential in improving food security by substituting rice. It is rich of nutrition and essential chemicals compounds, either as food or herbal. Product yield of job’s tear and quality need to be increased for obtaining flour for various food. This study aimed to investigate the physical and chemical properties of Job’s tear flour was subjected by wet milling and dry milling techniques. The result showed that wet-milled flour had higher value of moisture content compare to the dry-milled flour. Thermal properties of wet- and dry-mill were different each other. Conclusion temperature (Tc) - onset temperature (To) of dry-milled flour was statistically higher than wet-mill flour. The gelatinization enthalpy of wet-milled flour (11.2085 J/g) was higher than dry-milled flour samples (7.8542 J/g). Dry milling technique caused more damaged and had more various cracks, fissures and holes on the starch surface than wet.

1. Introduction
Job’s tear (Coix lacryma-jobi L.) is one of cereal grains which has potential to develop as food carbohydrate. Indonesia has large potential area for cultivating Job’s tear. However, data of production area of Job’s tear in Indonesia is unknown. Job’s tear is originally from East Asia, particularly Indonesia and East India, then spread across China, Egypt, Germany, Haiti, Hawaii, Japan, Panama, Malaysia, the Philippines, Taiwan, US and Venezuela. In Indonesia, particularly West Java, Job’s tear is not primary commodities.[1] Job’s tear has several important compounds which has good effect on human health due to high contain of protein and calcium. These compounds are higher level over rice and wheat.[2] Job’s tear predominantly contains carbohydrate (65%), protein (15%), moisture (11%), fat (6%) with trace minerals and vitamins such as calcium, phosphorus, niacin, thiamine, and riboflavin.[3,4]

In Indonesia, the utilization of Job’s tear for food uses is very limited. However, in several countries, Job’s tear has been utilized as food carbohydrate as well as wheat, such as ingredients in cakes and beverages, even as soup. In China, it can also be used as a medicine for rheumatic, neuralgia, and anti-inflammatory. Chen et al [5] also reported that Job’s tear grain contains flavonoid which knows as anti- inflammatory. Firulic acid was found in Job’s tear which has effects on slowing carcinogenic and cancer growth, and also avoid the virus spreads in human body.[6] Another study reported some health influences by consuming Job’s tear namely reducing osteoporosis risk.[7] Essential compounds in Job’s tear have good effect on human health. Thus, this grain can be categorized as functional food.

In general, cereal can be prepared as flour by wet- and dry-milling processes. The milling process can be made the differences to the physical and chemical properties of flour.[8-10] Best quality flour will
influence the end products. As reported by Rahman et al [11], acceptable flour should have a high viscosity and undergo low syneresis attribute. Therefore, this study aimed to determine physical and chemical properties of Job’s tear flour yielded by wet- and dry milling. This research would make a contribution toward the improvement in the quality of Job’s tear flour.

2. Materials and methods

2.1. Processing of Job’s tear flour

Processing of Job’s tear flour was done by wet- and dry milling as shown in Figure 1. To produce dry-milled Job’s tear flour, the grain was milled by a hammer mill after cleaning. On the other hand, wet-milled Job’s tear flour was produced as follow: the grain was cleaned and soaked in water overnight at room temperature, with ratio grain to water (3:1 w/w), then milled by hammer mill with adding water. Wet flour was then placed in the container and dried at 60°C for 8-12 h. Wet- and dry-milled flours were sieved and stored in sealed-plastic bag at 4°C.

![Figure 1. Production of Job’s tear flour from (A) dry-milling process and (B) wet-milling process](image)

Figure 1. Production of Job’s tear flour from (A) dry-milling process and (B) wet-milling process
2.2. Determination of physicochemical properties

Determination of physicochemical properties of Job’s tear flour were moisture content (SNI 01-2891-1992), ash content (SNI 01-2891-1992), protein by Kjeldhal (SNI 01-2891-1992).

2.3. Determination of pasting properties

Pasting properties of Job’s tear flour were determined using Rapid Visco Analyser (RVA). Job’s tear flour (3 g) was mixed in 25 mL of water until dough yielded. The dough was then stirred using RVA for 6 min at 60-95 °C. Starch granule was formed while heating due to swelling and became viscous. Temperature, time and peak viscosity were recorded.[12]

2.4. Thermal properties

Thermal properties of Job’s tear flour were examined by a Differential Scanning Calorimeter (Model Diamond, Perkin-Elmer DSC 8000, USA) following the method of Kim et al.[13]

2.5. Particle morphology analysis

Particle morphology was determined using scanning electron microscope (Jeol Model JSM-5800L, Japan). The samples were placed on an aluminium support using a double-sided adhesive tape with conductive carbon and then coated with platinum using a Cressington sputter coater 108 (Cressington Scientific Instruments, UK). The images were taken with the detector within the lens, using an acceleration voltage of 3.00 kV.[14]

3. Results and Discussion

3.1 Effect of wet- and dry-milling on chemical properties of Job’s tear flour

Chemical properties of Job’s tear flour is shown in Table 1. In term of moisture content, wet-milled flour had higher moisture content 10.446% over the dry-milled sample 8.1868%. This may be due to the additional of water during wet-milling process. Ash content was also found superior in wet-milled sample 0.1421% compared to dry-milled 0.0918%, it was because some trace minerals were diluted during wet-milling process. Protein content of Job’s tear flours was recorded lower in wet-milled sample over the dry-milled one, this low level of protein probably due to several amino acids, such as albumin wasted by soaking in water.[15]

Table 1. Chemical properties of Job’s tear flour produced by wet- and dry-milling process

| Parameter          | Type of process |
|--------------------|-----------------|
|                    | Wet-milling     | Dry-milling |
| Moisture content   | 10.4460         | 8.1868     |
| Ash content (%)    | 0.1421          | 0.0918     |
| Protein content (%)| 14.0050         | 15.2750    |

3.2. Effect of wet- and dry-milling on gelatinisation of Job’s tear flours

The processing of Job’s tear flour had significant results on the starch gelatinisation profile. The profile gelatinisation of Job’s tear is presented in Table 2. According to Lee and Osman [16], gelatinisation of starch is affected by amylose, lipid and amylopectin content. Amylopectin influences swelling rate and gelatinisation of starch granule, while amylose and lipid reduce the swelling rate.

Milling process also influenced pasting viscosity of the end flours. This may be due to the reduction of chemical properties of starch granules. Table 2 shows the profile viscosity of wet-milled flour greater compared to dry-milled one, particularly in peak viscosity. Peak viscosity of dry-milled flour had low value due to the breakdown of starch granules.[17] High viscosity shows water bounding ability of starch granules. The dry-milled flours had decay starch granules, thus the gelatinisation rate increased. Furthermore, the viscosity decreased by adding hot water.[18]
Low breakdown viscosity value of starch granules shows stable to heat process. Conversely, high breakdown viscosity value shows brittle starch granules which had swelled. Wet-milled flour had setback viscosity 884 cP, while dry-milled flour was -989 cP. High setback value can occur retrogradation easily, while low set back value shows hard retrogradation. It shows that dry-milled flour tend to have low recrystallization which was caused by milling process that breakdown the starch granules.[15]

Table 2. Gelatinisation profile of wet- and dry-milled of Job’s tear flour

| Properties       | Type of process | Wet-milling | Dry-milling |
|------------------|-----------------|-------------|-------------|
| Initial temperature (°C) | 69.6            | 71.2        |
| Initial time (s)   | 258             | 273         |
| Peak viscosity (cP) | 3958            | 2767        |
| Peak temperature (°C) | 87.7            | 79.5        |
| Peak time (s)      | 438             | 356         |
| Hot paste viscosity (cP) | 2516            | 1182        |
| Cold paste viscosity (cP) | 4842            | 1778        |
| Breakdown (cP)    | 1442            | 1585        |
| Setback (cP)      | 884             | -989        |

Figure 2. Pasting profile of (A) dry-milled Job’s tear flour and (B) wet-milled Job’s tear flour using Rapid Viscometer Analyser (RVA)

3.3. Effect of wet- and dry-milling on thermal properties of Job’s tear flour

Thermal properties of Job’s tear flour produced by wet- and dry-milling is shown in Table 3. It was observed that both thermal properties were different each other. Dry-milled flour had value of Tp, To and TC higher compared to those of wet-milled flour. It was possibly caused by the starch granules size where wet-milled flour had large size. Small size of granules causes ease to hydrated and gelatinised when appropriate temperature reached. On the other hand, large granules is hard to hydrate, therefore gelatinisation cannot occur (Tc-To).[7] In the case of gelatinisation enthalpy, dry-milled flour had 7.8542 J/g, it was lower over the wet-milled flour 11.2085 J/g. It indicates there was decay on the crystal structure of dry-milled flour. Difference of starch gelatinisation properties is influenced by trace minerals, starch granules size and shape of crystalline molecule.[19]
### Table 3. Thermal properties of wet- and dry-milled of Job’s tear flour

| Properties     | Type of process |
|----------------|-----------------|
|                | Wet-milling     | Dry-milling    |
| Tp (°C)        | 78.42           | 81.88          |
| To (°C)        | 77.01           | 81.98          |
| Tc (°C)        | 80.87           | 82.38          |
| ΔH (J/g)       | 11.2085         | 7.8542         |
| R (°C)         | 3.86            | 0.4            |

Tp, Peak temperature (°C); To, Onset temperature (°C); Tc, Conclusion temperature (°C); ΔH, Enthalpy (J/g).

#### 3.4. Particle morphology analysis using SEM (Scanning Electron Microscopy)

Figure 3 shows starch granules of Job’s tear flour produced using wet- and dry-milling. It was observed that both starch granules were oval and irregular size. Particles shape of dry- and wet-milled were slightly different each other. Dry-milled sample had rough surface and irregular sheets. Conversely, the wet-milled samples had smooth surface. It was observed that both starch granules of wet- and dry-milled flour had hexagonal holes using 3000 x magnification. It was because of milling process affected the starch granules.

![Scanning electron microscopy images of dry milled Job’s tear flour (A) and wet-milled job’s tear flour (B)](image)

Figure 3. Scanning electron microscopy images of dry milled Job’s tear flour (A) and wet-milled job’s tear flour (B)

#### 4. Conclusions

Two milling processes yielded different properties of Job’s tear flour. Wet-milled process had lower protein content, higher ash and moisture content compared to dry-milled flour. Wet-milling process increased viscosity, swelling and gelatinisation enthalpy. The wet-milling process is recommended for producing Job’s tear flour.
5. References

[1] Tati Nurmala, Warid Ali Qosim dan Tjutju S. Achyar. 2009. Eksplorasi, Identifikasi dan Analisis Keragaman Plasma Nuftah Tanaman Hanjeli (Coix lacryma-Jobi L.) Sebagai Sumber Bahan Pangan Berlemak di Jawa Barat. Laporan Penelitian Strategis UNPAD.

[2] Mahmud MK dan NA Zulfianto (Ed.). 2009. Tabel Komposisi Pangan Indonesia. Elex Media Komputindo Gramedia. Jakarta.

[3] Duke, J. A. 1983. Handbook of energy crops. Indiana: Purdue University, Center for new crops & plants products.

[4] Yang, J., Tseng, Y., Chang, H., Lee, Y. and Mau, J. 2004. Storage stability of monascal adlay. Food Chemistry 90: 303-309.

[5] Chen, H.-J.; Chung, C.-P.; Chiang, W.; Lin, Y.-L. Anti-inflammatory effects and chemical study of a flavonoid-enriched fraction from adlay bran. Food Chem. 2011, 126, 1741–1748.

[6] Chung, C.-P.; Hsu, H.-Y.; Huang, D.-W.; Hsu, H.-H.; Lin, J.-T.; Shih, C.-K.; Chiang, W. Ethylacetate fraction of adlay bran ethanolic extract inhibits oncogene expression and suppresses DMH-induced preneoplastic lesions of the colon in F344 rats through an anti-inflammatory pathway. J. Agric. Food Chem. 2010, 58, 7616–7623.

[7] Jitrarut leewatchararongjaroen and Jirarat anuntagool, 2016. Effects of Dry-Milling and Wet-Yang, R., Lu, Y., Chiang, W. and Liu, S. 2013. Osteoporosis prevention by adlay: The seeds of Coix lacryma Jobi L. var. ma-yuen stapf in a mouse model. Journal of Traditional Complementary Medicine 3(2): 134-138.

[8] Chen, J. J., Lu, S. and Lii, C. Y. 1999. Effects of milling on the physicochemical characteristics of waxy rice in Taiwan. Cereal Chemistry 76: 796-799.

[9] Chiang, P. Y. and Yeh, A. I. 2002. Effect of soaking on wet-milling of rice. Journal of Cereal Science 35: 85-94.

[10] Yoenyongbuddhagal S, Noomhorm A. 2002. Effect of physicochemical properties of high-amylose Thai rice flour on vermicelli quality. Cereal Chem, 79(4): 481–485.

[11] Rahman, M. S. 1999. Food preservation by freezing. In Rahman, M. S. (Eds). Handbook of food preservation, p. 259-284. New York: Marcel Dekker.

[12] WMC (Wheat Marketing Center). 2004. Wheat and Flour Testing Methods. Portland: Wheat Marketing Center, Inc.

[13] Kim Y S, Wiesenborn D P, Orr P H, Grant L A. 1995. Screening potato starch for novel properties using differential scanning calorimetry. J Food Sci, 60(5): 1060–1065.

[14] Darniadi S, Ho P, Murray BS. Comparison of blueberry powder produced via foam-mat freeze-drying versus spray-drying: Evaluation of foam and powder properties. J Sci Food Agric 2017; 98: 2002–2010.

[15] Suksomboon, A. and Naivikul, O. 2006. Effect of dry- and wet-milling processes on chemical, physicochemical properties and starch molecular structures of rice starches. Kasetsart Journal (Natural Science) 40: 125-134.

[16] Lee Y E, Osman E M. 1991. Correlation of morphological changes of rice starch granules with rheological properties during heating in excess water. J Kor Agric Chem Soc, 34(4): 379–385.

[17] Yoenyongbuddhagal, S. and Noomhorm, A. 2002. Effect of raw material preparation on rice vermicelli quality. Starch/Stärke 54: 534.

[18] Wadcharat, C., Thongngam, M., dan Naivikul. O. 2006. Characterization of pregelatinized and heat moisture treated rice flours. Kasetsart Journal, 144-153.

[19] Kaur, A., Singh, N., Ezekiel, R., & Guraya, S. H. (2007). Physicochemical, thermal and pasting properties of starches separated from potato cultivars grown at different locations. Food Chemistry, 101, 643-651.