Applying physical and aerodynamic properties of saffron for separating stigma from the other parts of flower

B. Emadi[1]; M.H. Saiedirad[2]; A. Mahmoodi[3]

[1,3]Department of Agricultural Machinery, Ferdowsi University of Mashhad

Azadi Square, P.O.Box 1163, Mashhad, Iran

[2]Technical and Engineering Research Centre, Khorasan Razavi, Mashhad, Iran

E-mail of corresponding author: emadi-b@ferdowsi.um.ac.ir, Bagher_emadi@yahoo.com

Abstract

Selected aerodynamic and physical properties of saffron flower aiming to assess the possibility for separating stigma from the other parts of flower were investigated. Terminal velocity of the flower parts including petal, stigma and anther in addition to their static frictional coefficient were determined on three different materials including wood, rubber and steel. The measurements were conducted in four days after saffron harvesting. The results proved the possibility of separation using both properties including terminal velocity and static coefficient of friction. It is also disclosed that using both properties on first day of harvesting can lead to the best separation.

Keywords: physical properties, aerodynamic, saffron

Introduction

Saffron (*Crocus Sativus*) is one of the most expensive edible flowers of the world. With a production of about 170 tones of dried saffron, which is approximately 81% of the world's production of saffron, Iran is considered to be the main producer of dried saffron all over the world (Ebrahimzadeh, 2006). The second producer with about only 12% of the world's saffron production is Spain. A farm of saffron needs daily and manually harvesting because every plant of saffron produces only three flowers in different height and days. There are 2170 flowers in each kilo of harvested fresh flower, and processing every 78 kilos of fresh flowers results in one kilo of dried saffron. This final product is actually the stigma part of flower (Fig. 1). The stigma, as the only economic part of flower has eatable and medicinal applications. The stigma has three branches which are connected together at the bottom. Harvest and post-harvest operations should be conducted warily to avoid any harmful effect on taste, color, and odor of stigma. The manual harvesting, including cutting and picking up the whole flower should be carried out daily before sunrise. It reduces the quality of flower in addition to moisture content which it seems that it has a significant effect on flower processing. A post-harvest operation includes stigma separation from the other parts of flower in the shortest period of time before drying up the harvested flowers. All operations are currently carried out manually.

Figure 1: The image of saffron flower and its main parts

Operation mechanization of harvest and post-harvest of saffron flower is economically important due to time limitation, daily harvesting, and possible contamination due to manual operations. The stigma separation is one of the most laborious and expensive operations. Particle separation using aerodynamic properties have been introduced by industry in addition to many researches such as El-Sayed, Yahaya, Wacker, Kutzbach (2001). Separation is usually carried out using terminal velocity of aimed particles which is supposed to be separate from the rest of the mixture with different terminal velocities. The applied apparatus is named a vertical wind tunnel.

In the current study, the possibility of stigma separation from the other parts of flower using physical and aerodynamic properties of saffron flower was investigated. The aim of the study was to increase the level of mechanization and efficiency of post-harvest operations. Saffron flower was divided to the three main parts, including petal, anther and stigma.

Aerodynamic properties involving terminal velocity of different parts of flower was identified. The properties were investigated on different days after harvest because the properties of agricultural produce are moisture content dependant (Ozguven, Vursavus, 2005; Aydin, 2002; Demir, Akinci, 2004). The results showed that the separation of stigma from the other parts is definitely possible due to a significant difference of their terminal properties, especially on the first day of harvesting.

Materials and methods

Preparing flower parts

Saffron flowers were provided from farms around Mashhad in Khorasan Razavi province, Iran. Flowers were taken directly to the lab in the shortest period of time. They were kept in a dark store with environmental temperature and humidity during four days after harvest. The flowers were taken out daily from the store and each flower was cut from the receptacle point and divided to three parts; namely, stigma, petal and anther. The values of moisture content of flower parts in different days are shown in Table 1.

Table1. Moisture content (%) of three parts of saffron during four days from harvesting (wet basis)

	1^{st} day	2^{nd} day	3^{rd} day	4^{th} day
Stigma	85.2	72.6	42.1	26.6
Anther	68.6	16.6	12.6	7.4
Petal	79.1	46	17.6	11.6

Determination of aerodynamic properties

The terminal velocity of each part was experimentally measured using the floating method. This method provides blowing air in a vertical duct for produce particles to be floated. The air speed at the time of floating is measured by a digital hot wire anemometer and it is called terminal velocity. At the time of floating, the weight of particles is equal to the drag force (Mohsenin, 1986). A vertical air duct (Fig. 2a) which was designed and fabricated in the Agricultural Research Center of Mashhad (Iran) was used for measuring terminal velocity of saffron flower parts. The duct can provide variable air stream with changing the frequency of electric motor supplier.

A hot wire anemometer with an accuracy of 0.1 m/s was applied for experiments. The environmental temperature was 15 ºC and experiments were repeatedly conducted during four days from harvesting (four level of moisture content shown in Table 1). The experiments were carried out for three parts of saffron flower, including stigma, anther and petal and each was repeated 5 times.

Determination of static coefficient of friction

Measuring the static coefficient of friction was conducted using an adjustable tilted plane (Fig. 2b). It was pivoted from one end and could be tilted from another end by a wire with adjustable length. The plane could be equipped with different materials including wood, stainless steel, and rubber. The samples were placed on the plane and it was tilting by shortening the connected wire until the samples started to fall. The angle of plane recorded as static coefficient of friction. The experiments were carried out during four days (four different levels of moisture contents) started from harvesting for three parts of flower including stigma, anther and petal. The experiments repeated three times each.

(a) (b)

Figure 2: The applied measuring apparatus a) The vertical air duct which used for measurement of terminal velocity b) Adjustable tilted plane

Results and discussions

The results of terminal velocity measurement for different parts of saffron flower throughout four days after harvest are shown in Fig.3. There was a significance difference among the values of terminal velocity for different parts and moisture contents. The maximum difference was on the first day of harvesting. The terminal velocity ranged from 2.4 to 2.8 m/s and between 1 and 2 m/s for stigma and other parts respectively. The results support the idea of the possibility for separating stigma from the other parts of the flower using terminal velocity. The possibility of separation is high, especially on the first day of harvesting. It puts emphasis on the belief of traditional farmers that the first day of harvesting is the best day for stigma separation.

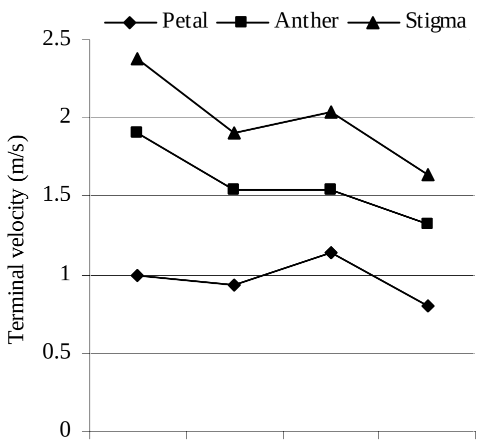

Figure 3: The terminal velocity of flower parts during four days after harvest

The results of static coefficient of friction measurement for three parts of saffron flower on three different materials are illustrated in Fig. 4. The comparison of the results on different materials revealed the significance difference among measured static coefficient of friction for flower parts of saffron on wood. This material of plane showed higher difference between coefficient of stigma and the other parts of flower on the second day than the other days of harvesting. The values of this measured parameter for stigma and the other two parts were close on the materials of plane including rubber and stainless steel.

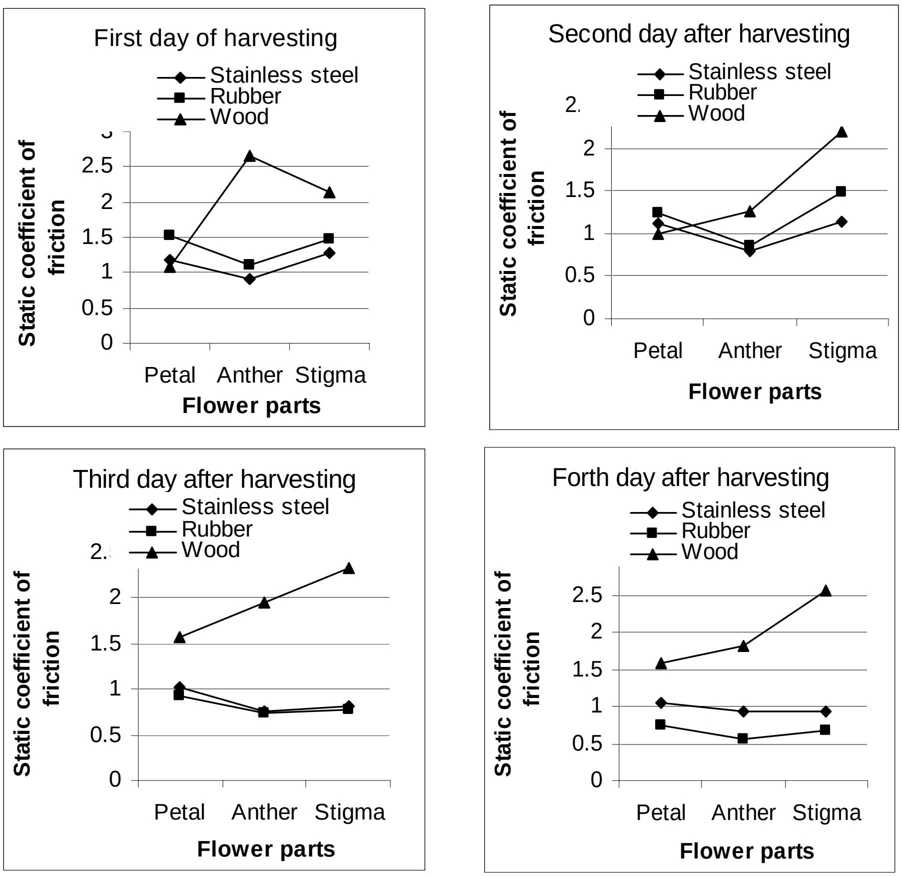

Figure 4: The static coefficient of friction for saffron flower parts during four days after harvest

In conclusion, the possibility of stigma separation from the other parts of saffron flower using terminal velocity and static coefficient of friction on wood material of plane was disclosed.

REFERENCES

Aydin, C (2002). "Physical properties of hazel nuts," *Biosystems Engineering*, 82, pp 297-303.

Ebrahimzadeh, H, Rajabian, T, Abrishamchi, P, Karamian, R, Sabura, O (2006). *"Iranian Saffron in a Research View,"* Nashr e Ettlaat Publisher.

El-Sayed, AS, Yahaya, R, Wacker, P, Kutzbach, HD (2001) "Characteristics attributes of peanut (Arachis hypogaea L.) for its separation," *International Agrophysics*, 15, pp 225-230.

Demir, F, Akinci, I (2004). "Physical and nutritional properties of four major commercial Turkish hazelnut varieties," *Journal of Food Engineering*, 63, pp 341–347.

Mohsenin, NN (1980). *"Physical properties of plant and animal materials* (2nd ed., pp.238-241), New York: Gordon and Breach Science Publishers.

Ozguven, F, Vursavus, K (2005). "Some physical, mechanical and aerodynamic properties of pine (*Pinus pinea*) nuts," *Journal of Food Engineering* **, 68, pp** 191–196.