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Saffron Stigma Separation by Oscillating Seperator and Wind Tunnel

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Abstract

Quality is an important factor in food products marketing, in the agricultural products, which the lack of agricultural equipment effects on it. Nowadays, separator devices play an important role in the quality of agricultural products. In this study, the separation of stigma from other components is analysed in oscillating separator, wind tunnel and combination of two states for determining their transposition. Oscillating separator experiments were performed based on completely randomized factorial design with 3 treatment of slope, amplitude, frequency and 3 replicates that each treatment is carried out at two levels. Considering that saffron components terminal velocities were different therefore wind tunnel experiments were done at different speeds within the range of saffron components terminal velocities. The results show that the combination of "wind tunnel-oscillating seperator" had the best seperation. In the oscillating seperator, the frequency of 35 Hz, amplitude of 7 μ and slope of 10˚ in comparison with other states had the optimum seperation. This combination was followed the average stigma separation of 86.29% and percent of impurities of 14.14%.

Keywords: seperation, oscillating separator, wind tunnel, frequency, amplitude

1. Introduction

Saffron is a spice derived from the flower of *Crocus sativus*, commonly known as the saffron crocus. *Crocus* is a genus in the Iridaceae family. Saffron flowers that take accont as the product of farm, include white carpel, three vivid crimson stigmas, three stamens, three same color sepal and petal that number of sepal and petal in usual flowers is six (Figure 1). Who stigma and a part of carpel from the other components is separated then the product is dried and sold as commercial saffron.

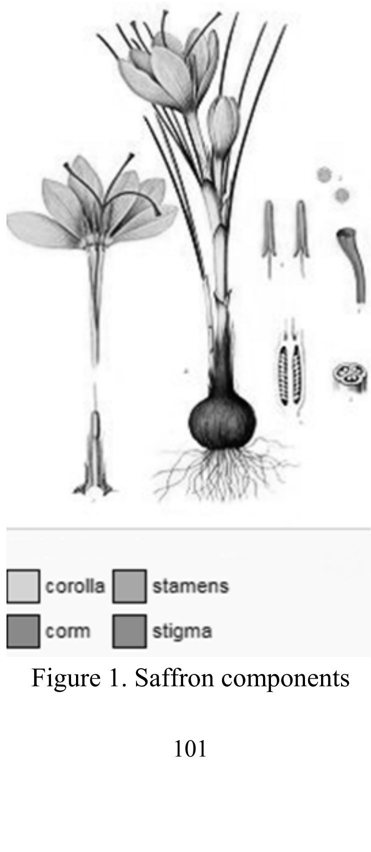


Figure 1. Saffron components

In the recent researches, petals were used in production of food color due to anthocyanin pigments (Hemmati et al., 2001), and saffron leaves can be considered for animal nutrition (valizadeh et al., 1899). According to the mentioned contents and applications of saffron in the pharmaceutical and coloring industry, it can be realized the importance of saffron separating. In the other hand, arranged flowers in one day should be opened on the same day, so, the flower pipe is splitted and the carpel is taken with three red stigmas within the flower pipe by the nail (Abrishami, 1897) which contributes to the pollution of saffron and reduction of its quality.

Agricultural products can be distinguished, usually based on shape, dimensions, physical properties and aerodynamic properties (Borgeie, 1974). Separation based on the aerodynamic properties is the oldest separation, by this method the seeds are put exposed to the air flow. To separate the stigma from flower, Emadi et al. (2008; 2009) and Vale Ghozhdi et al. (2010) used physical and aerodynamic properties. The terminal velocity of flower components such as stigma, petals and stamen have been determined by the wind tunnel and results showed that it was possible to separate the stigma in harvesting moisture. In another study, Paschino and Gambella (2008) compared three models of cyclones with various structures such as the duct diameter, air velocity and the separation surface for the mechanical separation of saffron stigmas in the air flow. Results showed that cyclone type 3 which reduces the duct diameter by 14% and speed of the air included between 0.69 m/sec and 1.5 m/sec, the separation performed (96% of separate stigmasand without any damage in stigmas. In the separation based on friction coefficient, separation process is based on difference in the friction angle of mixture components. In this field, Emadi (2009) and Vale Gozhdi (2010) have taken a similar conclusion that there was a possibility of separating saffron components with this property. Hassan Beygy et al. (2010) studied the physical properties of saffron corm and determined the average values of the coefficient of friction for the three corm regions on steel, galvanized steel, plywood, rubber and polyethylene sheets: 0.517, 0.404, 0.462, 0.584 and 0.402, respectively. Electrostatic separating method is based on alternating absorption or desorption of charged particles in an electric field. Bani Hashemi et al. (2010) investigated the possible separation of impurities in the saffron, for example, chosing the nails. The results of the experiments showed the purification of the nail by 72%.

Other researches were carried out in separating such as researches on pea (Kiliçkan & Güner, 2010), cotton (Kiliçkan & Güner, 2006), barley, sunflower, lentil (Guner, 2006), pistachio (Sadegi et al., 2008), peanut (El-sayed et al., 2001), and wheat (Rasekh et al., 2005; Guner, 2006).

According to these studies, we observed that there were no researches about the stigma separation by oscillation separator, wind tunnel and combination in 2 states (oscillator-wind tunnel, wind tunnel-oscillator), and there were also no researches about influential parameters on oscillation seperator such as slope, frequency, amplitude on saffron separating. Therefore, it’s important to separate the components of saffron, especially stigma.

2. Materials and Methods

2.1 Preparation of Samples

Saffron grows in limited regions of Iran, such as Khorasan, Fars, Yazd, Kerman, Markazi, Semnan, East Azarbaijan, and the production of it in the most provinces is new, except Khorasan and Fars. Samples were picked on farms located in the city of Marand in East Azarbaijan, then samples were cut from the upper receptacle by scissors, and the various components such as petals, leaves, stamens and stigmas were separated. The saffron components were dried in the oven at 103°C for 24 hours (ASAE S358.2 FEB03) to determine the moisture content.

$$MC_{wb} = \frac{W_i - W_d}{W_i} \times 100 \qquad (1)$$

That:

MC_{wb} : Moisture content, based on wet, (%)

W_i : The initial mass of sample, (g)

W_d : The dried mass of sample, (g)

Experiments were repeated 3 times to determine the initial moisture and took the average value as the initial moisture.

2.2 Seperation

In this experiment, 2 separator devices were used including oscillating seperator and wind tunnel with test section diameter of 17 cm with different speeds. Oscillation Separator is made up a “Sinocera Piezotronics Inc” oscillator, model JZK-2 and a screen (length: 32 cm and width: 22 cm) screwed on oscillator as shown in Figure 2.

Figure 2. "Sinocera Piezotronics Inc" oscillator

This seperator was able to work in the various slopes of frequencies and amplitudes. Oscillating separator experiments were performed on 2-3 g samples randomized factorial designed with 3 treatment of slope, amplitude, frequency and 3 replicates that each treatment was carried out at two levels. Due to lack of sufficient information about the frequency, amplitude and the slope for stigma separation, 3 g of controlled samples were used to determine the frequency, amplitude and slope of the tests. The sample feed an oscillating seperator steep screen by a chute and tested with variety of amplitudes, frequencies and slopes. The optimal values have been presented in Table 1.

Table 1. Variable values of oscillating seperator

condition	optimal values	
Frequency (Hz)	30	35
Amplitude (μ)	5	7
Slope (degree)	10	15

Considering that saffron components terminal velocities were different therefore wind tunnel experiments were done at different speeds within the range of saffron components terminal velocities to achieve the optimum speed for separation.

To determine the effect of separation systems transposition, two combinations were tested:

1) Oscillating seperator-wind tunnel

2) Wind tunnel-Oscillating separator

After determination of two separation stages percent of each combination, total separation percent of each combination was defined as first stage separation percent multiplied by the second stage Separation percent:

$$P.S_{total} = P.S_1 \times P.S_2 \tag{2}$$

That:

$P.S_{total}$: Total Separation percent, (%)

$P.S_1$: First stage Separation percent, (%)

$P.S_2$: Second stage Separation percent, (%)

2.2.1 Oscillating Seperator-Wind Tunnel

Experiments were performed in two stages. First samples were tested by oscillating seperator, and then oscillating output was used as an input in the wind tunnel.

2.2.1.1 Oscillating Seperator

Before the test the amounts of each part of flowers was weighed by digital scale with an accuracy of 0.01 g. For testing, first oscillating separator was set on frequencies, amplitudes and slopes and then vibration is started and the sample was fed on a steep screen. Saffron components on the screen have been started to vibrate and each part took distance from other parts. Finally, after passing the length of oscillator screen, the amount of each part in the oscillator output was recorded. The optimal time for obtaining the maximum stigma separation percent in output was also noted. For determination of stigma separation percent, stigmas in the separator output were devided to its input value:

$$Seperation\ Percentage=\frac{Material\ in\ output}{Material\ in\ input}\times 100 \qquad (3)$$

2.2.1.2 Wind Tunnel

According to Emadi (2009) and Vale Gozhdi (2010), the terminal velocities of saffron components have significant difference with each other which can be used for separation. For this purpose, first a 3 g controlled sample was applied to determine the range of separation speed at three replications. To measure the air speed, the hot wire speedometer of model “Yk-2004ah” with an accuracy of 0.1 m/s was used. Seperator evacuation materials have been fed into the wind tunnel test section by achute. Air speed was changed in the range of separation speed by the inverter and diaphragm until at the optimal speed, the highest percent stigmas separation was achieved. The output weighing of the wind tunnel was measured by scale and stigmas separation percent was determined according to Equation (2).

2.2.2 Wind Tunnel-Oscillating Separator

In this combination, the experiment was performed in two stages according to previous combination. Method of tests is on the basis of previous combination with a difference that first eight wind tunnel, separation tests were performed with 3 replications and the output materials were used for the input of the oscillating separator.

3. Results and Discussion

3.1 Initial Moisture Content

The results of initial moisture content of saffron components based on wet have been shown in Table 2. These values are the average of 3 replications.

Table 2. The initial moisture content of saffron components based on wet

Sample	Petal	Stigma	Stamen	Leaf
Initial moisture content	87.2%	77.4%	66.7%	56.1%

3.2 Oscillating Separator-Wind Tunnel

3.2.1 Oscillating Separator

Average and variance analysis of stigma separation data were calculated by excel 2007 and MS-TAT. Results of variance analysis of three treatments (frequency, amplitude and angle of slope) on the stigma separation percent has been shown in Table 3. Effects of two factors including frequency and amplitude on the separation percent are significant in the probability level of 1%. Frequency × amplitude and frequency × slope angle interaction effects and even effect of frequency × amplitude × slope angle on the separation percent is significant in probability level of 1%.

Table 3. Variance analysis of treatments on stigma separation percent at second combination

Variation resources	Degrees of freedom	Mean squares
Frequency	1	157.082**
Amplitude	1	7.935**
Slope angle	1	518.940
Frequency × Amplitude	1	19.082**

Frequency × Aope angle	1	121.5**
Amplitude × Slope angle	1	22.427
Frequency × Amplitude × Slope angle	1	105.840**
Error	16	9.364
Coefficient of variation		3.31%

** Significant in probability level of 1%

To achieve higher percent of stigma, separation average of oscillating separator, optimum time, etc. at various levels of treatments are shown in Table 4.

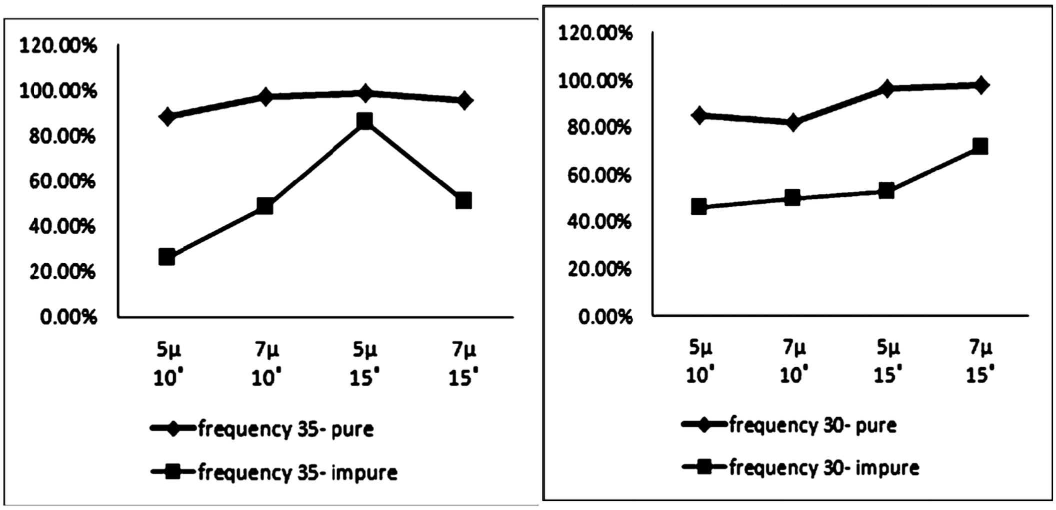
Table 4. Stigma and impurities average seperation values and optimum separation time at first combination

Test number	Treatments value	Separation average	Impurities average	Optimum time
1	Frequency:30 Hz Amplitude:5μ Slope: 10˚	84.47%	45.50%	22
2	Frequency:30 Hz Amplitude:7μ Slope: 10˚	81.57%	49.60%	14
3	Frequency:35 Hz Amplitude:5μ Slope: 10˚	88.1%	26.30%	16
4	Frequency:35 Hz Amplitude:7μ Slope: 10˚	97.17%	48.70%	14
5	Frequency:30 Hz Amplitude:5μ Slope: 15˚	96%	52.60%	14
6	Frequency:30 Hz Amplitude:7μ Slope: 15˚	97.63%	71.30%	12
7	Frequency:35 Hz Amplitude:5μ Slope: 15˚	99.03%	75.60%	12
8	Frequency:35 Hz Amplitude:7μ Slope: 15˚	95.83%	47.60%	6

According to the observations and results of the stigma and impurity average separation, the best separation with high quality is achieved in frequency of 35 Hz, slope of 10˚, amplitudes of 5 and 7 μ. In these characteristics, stigma separation is in high level while the impurity percent is low. In these two optimum cases, output impurities have the lowest leaves and petals than any other cases. The main reason of stigma reduction in output is related to saffron petals. Petals surround the stigmas and don't allow the stigmas to vibrate. This shows that the initial bulk of sample is one of the parameters that have an effect on separation.

The time and frequency is inversely proportional to each other and Table 4 depicts it. By increasing the frequency, the time for optimum separation are reduced. As in experiment No. 8, all inputs were observed in the seperator output with increasing a little time. It means that no separation has occurred to any of the components. According to this, we observed the time is effective on oscillating separation as the length of plate is effective.

In Figure 3, percent of pure and impure materials separation diagrams are given in constant frequencies and the effects of amplitude on stigma separation percent have been investigated. In diagram (3-a) the best separation point has occurred in slope of 10˚ and amplitude 5 microns with the average stigma separation percent of 88.10% (less than the others) but the low difference of stigma separation percent compared to others to its low percent of impure and also the high difference in the percent of impurity to others have caused this point of separation to be better in frequency of 35 Hz. Experiment No. 7 (frequency: 35 Hz, amplitude: 5μ, slope: 15˚) has the lowest difference between pure and impure graphs. This means, the time or length of plate should be less for separating process because of high frequency but the plate is constant for each test, therefore the time is effective on this test. At this point, the high impurities percent is related to low separation time (With comparing the percent of pure and impure diagrams in (3-b)). For having the highest percent of pure versus the lowest percent of impurity, amplitude of 5 microns with slope 15˚ had the best separation.

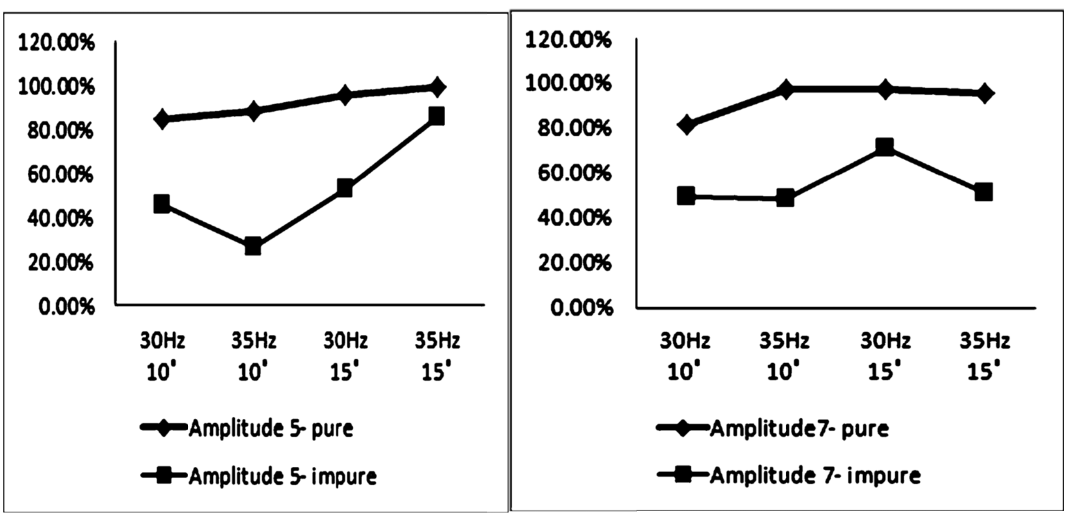


(a) (b)

Figure 3. Pure and impure separation percent in constant frequencies of 30, 35 Hz at first combination

Comparing the Figures (3-a) and (3-b) it is concluded that, in two mentioned frequency and slope, amplitude of 5μ gives a reasonable answer, for this level of separation.

In graphs of Figure 4 pures and impures separation percent have compared with each other in a constant amplitude and the effects of frequency on each separation percent has been investigated. In Figure (4-a), the highest stigma separation is in frequency of 35 Hz and slope of 15˚ with the average of 99.03% and impure percent of 85.60%. In fact, there is no separation between pures and impures. But in two states of (frequency: 30 Hz, slope: 15˚) and (frequency: 35Hz, slope: 10˚), the separation is better. Considering the above points, in graph (4-b) the best separation has been performed in frequency of 35 Hz and slope 10˚ with an average of 97.17% and impure percent of 48.70%.



(a) (b)

Figure 4. Pure and impure separation percent in constant amplitudes of 5, 7 μ, at first combination

Comparing the two Figures (4-a) and (4-b) shows that at two levels of mentioned amplitudes, frequency 35 Hz and a slope of 10˚ are the best separation in comparison with other values.

So, if we chang the oscillator plate with the longest one, we can expect to increase the stigma separating by increasing the time of the separation.

3.2.2 Wind Tunnel

Average values of stigma separation by the wind tunnel are given in Table 5. Air velocity values varies in the range of 1.9-3.5 m/s. According to the observations, the stigma was lost because the amount of saffron was involved in the samples holding mesh and vibration was required for their release. Because of the components types the most impurities were existing in the input. When the speed of air is increased within the terminal velocity range of 1.9 m/s, stigmas are separated from the other components. But the stamens and leaves because of closely terminal velocity to the stigma terminal velocity of 3.6 m/s, in output being visible with stigma. On the other hand most experiments in oscillating seperator had more stigmas than the others components in output. As mentioned, we can optimize the wind tunnel with connecting the vibrator or use the air in oscillating seperator to increase seperation percent in second stage.

Table 5. Stigma and impurities seperation percent in wind tunnel at first combination

Test No.	Stigma percent	Impurities percent
1	85.13%	43.12%
2	85.07%	39.50%
3	91.03%	68.31%
4	89.83%	48.20%
5	83.73%	45.14%
6	71.17%	24.73%
7	68.80%	28.40%
8	78.57%	51.91%

In Figure 5, the percent of stigma separation and impurities percent graph have been shown. As known in the figure, the percent of stigma separation in experiments 3 and 4 is the most of other values but at the same time, has the most impurities percent. Because the stigmas and leaves were the main impurities observed in these two experiments and the amount of petals is close to zero, thus the stigma and leaves in the output of wind tunnel are seen due to closely terminal velocity to stigma. According to aforementioned results, second separation by wind tunnel isn't necessary if we remove petals in first separation by oscillating separator. Removing the petals can be performed by creating obstacles such as a number of thin rods with same distance and parallel with each other which are placed on the oscillating separator in several rows.

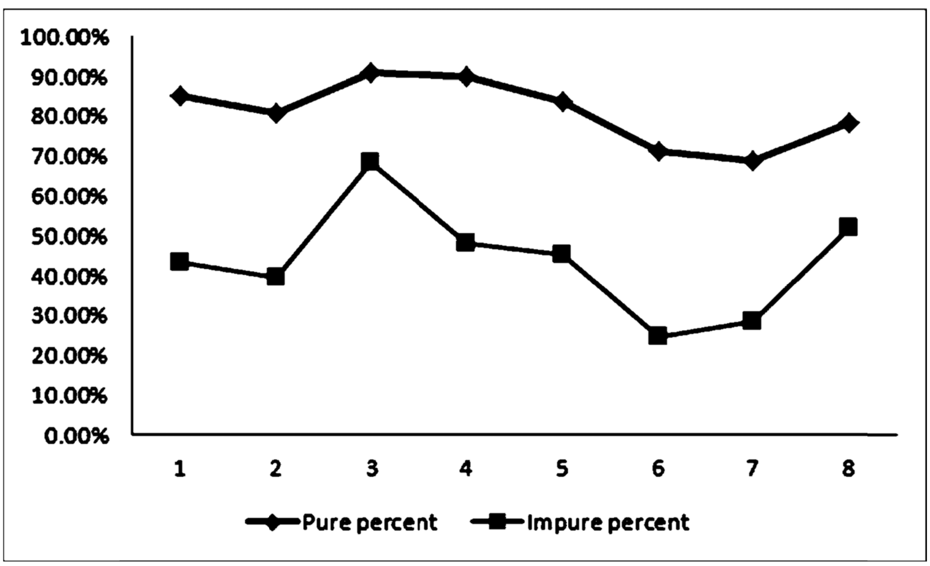


Figure 5. Pure and impure separation percent in wind tunnel at first combination

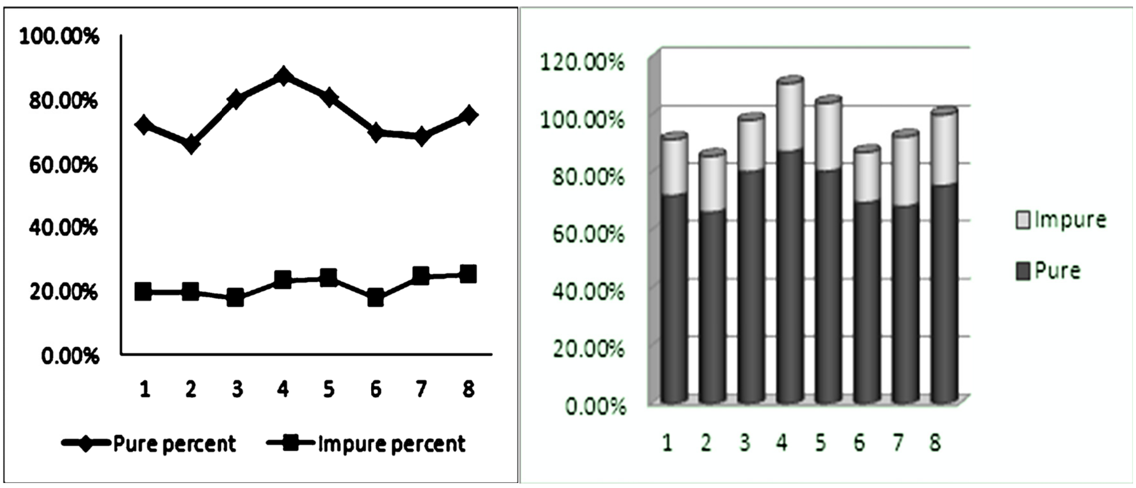
3.2.3 General State of Oscillating Seperator-Wind Tunnel

In general state, we have combined two states of oscillation and wind tunnel and formula of No. 2 is used for explaining data. The mean values for general state has given in Table 6. According to the Table 6, it is khown that the highest mean stigma is related to experiment of 4 with 87.29% stigma separation and the lowest percent of impurities is related to experiments of 3 and 6 with 17.96% and 17.61% impurities separation, respectively.

Table 6. Stigma and impurities seperation percent in first general combination

Test No.	Stigma percent	Impurities percent
1	71.91%	19.61%
2	66.12%	19.59%
3	80.20%	17.96%
4	87.29%	23.47%
5	80.38%	23.72%
6	69.48%	17.61%
7	68.13%	24.31%
8	75.29%	14.81%

Stigma and impure separation percent have been shown in Figure (6-a). Maximum separation with minimum impurities has clearly identified in experiments of 3, 4 and 5. In Figure (6-b) by comparing the values of impurities and pures of experiments 3, 4 and 5 can be found that experiment of 4 has the best result because of more total initial sample and low percent of impurities versus the high pure percent. After experiment of 4, experiments of 5 and 3 have the best response to stigma separation, respectively.



(a) (b)

Figure 6. Pure and impure separation percent in first general combination

3.3 Wind Tunnel-Oscillating Separator

3.3.1 Wind Tunnel

Average values of stigma separation by the wind tunnel are given in Table 7. Air velocity varied in the range of 1.9-3.7 m/s. This time, the input of wind tunnel input was similar to experiments in terms of size and type of components. The observations show that we need more air speed to separate stigma from others because of the petals that covered the other components. This show, the good separation with wind tunnel requires initial separation to reduce impurities compactness. During the samples nutrition, some leaves, stamens and stigmas placed on petal and cause high weight, so, Petal Terminal velocity were increased close to stigma terminal velocity.

Wind tunnel has more impurities at first stage of seperation in comparision with the wind tunnel in second stage, especially petals. This results show that the type of feeding is important, if we change the feeding type or large chute dimensions, we can expect that, the mentioned problems will not be repeated again in wind tunnel.

Table 7. Stigma and impurities seperation percent in wind tunnel at second combination

Test No.	Stigma percent	Impurities percent
1	91.10%	63.22%
2	85.87%	67.70%
3	91.32%	49.47%
4	95.21%	61.18%
5	89.10%	44.63%
6	97.96%	75.87%
7	82.74%	52.31%
8	96.70%	49.32%

The graph of stigma and impurities separation percent has been shown in Figure 7. As is clear in the graph, stigma separation percent in Tests No. 4, 6 and 8 are higher than others with averages of 95.21%, 97.96%, 96.70%, respectively. However, we observed that Stigma and impurities separation percent are in the range of 82.74%-97.96% and 44.63%-75.87%, respectively. That both are more than wind tunnel output in first combination.

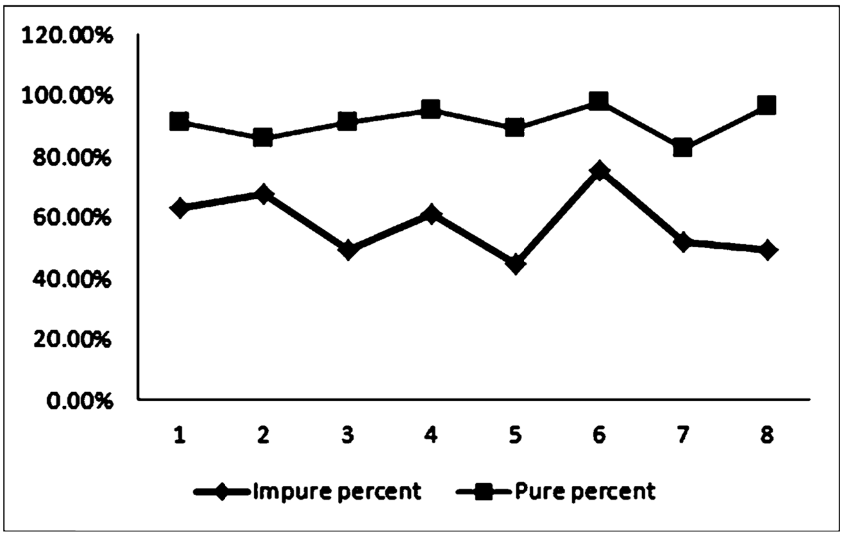


Figure 7. Pure and impure separation percent in wind tunnel at second combination

3.3.2 Oscillating Separator

Separation average of oscillating seperator and optimum time, to achieve higher percent of stigma, at various levels of treatments are shown in Table 8.

Table 8. Stigma and impurities average seperation values and optimum separation time at second combination

Test number	Treatments value	Separation average	Impurities average	Optimum time
1	Frequency:30 Hz Amplitude:5µ Slope: 10˚	89.55%	52.31%	19
2	Frequency:30 Hz Amplitude:7µ Slope: 10˚	85.63%	41.80%	13
3	Frequency:35 Hz Amplitude:5µ Slope: 10˚	91.70%	31.24%	14
4	Frequency:35 Hz Amplitude:7µ Slope: 10˚	90.63%	23.12%	12
5	Frequency:30 Hz Amplitude:5µ Slope: 15˚	89.75%	49.68%	13
6	Frequency:30 Hz Amplitude:7µ Slope: 15˚	93.95%	63.35%	10
7	Frequency:35 Hz Amplitude:5µ Slope: 15˚	90.66%	70.50%	9
8	Frequency:35 Hz Amplitude:7µ Slope: 15˚	84.88%	51.49%	6

According to the observations and results of the stigma and impurity average separation, the best separation with high quality is achieved at the frequency of 35 Hz, slope of 10˚, amplitudes of 5 and 7 µ. In these characteristics, stigma separation is in high level while the impurity percent is in low level. In these two optimum state, output impurities have the lowest leaves and petals of zero. In this mode of combination, there is less Impurity in the input an oscillating seperator because of reducing impurities in the first stage. So we can conclude that separation time is reduced with high quality separation, if obstacles againest the stigma vibrating reduced.

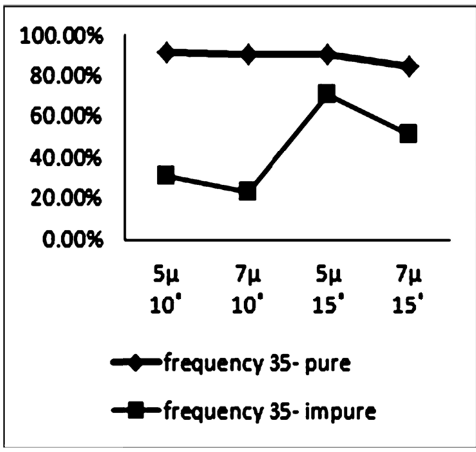
Results of variance Analysis of three treatments (frequency, amplitude and angle of slope) on percent of the stigma separation has been shown in Table 9. Effects of two factors frequency and slope on the percent of separation are significance in probability level of 1%. Interaction effects of frequency × slope angle on the percent of separation is significant in probability level of 1%.

Table 9. Variance analysis of treatments on stigma separation percent at second combination

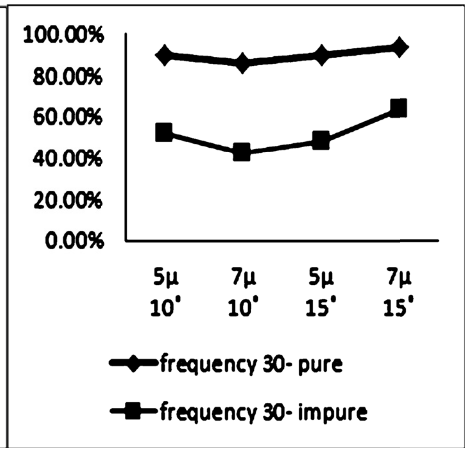
Variation resources	Degrees of freedom	Mean squares
Frequency	1	0.385**
Amplitude	1	16.203
Slope angle	1	1.127**
Frequency × Amplitude	1	19.117
Frequency × Aope angle	1	88.090**
Amplitude × Slope angle	1	4.386
Frequency × Amplitude × Slope angle	1	61.696
Error	16	14.899
Coefficient of variation		4.31%

** Significant in probability level of 1%

In Figure 8, the percent of pure and impure materials separation diagrams are given for constant frequencies and the effects of amplitude and slope on percent of stigma separation have been investigated. In Figure (8-a) the best separation point has occurred in slope of 10˚ and amplitude 7 microns with average stigma separation of 90.63% and impurities percent of 23.12%. In Figure (8-b), for having the highest percent of purity versus the lowest percent of impurity and by comparing percent of pure and impure percent diagrams, it is concluded that amplitude of 7 microns with slope 10˚ had the best separation. With comparing the two Figures (8-a) and (8-b), it is understood, that for two mentioned frequency with slope of 10˚, amplitude of 7 μ gives a reasonable answer.



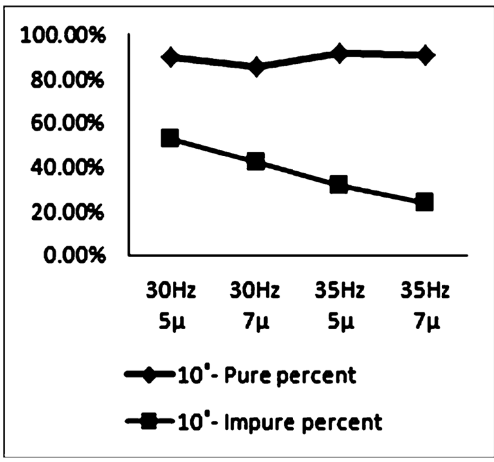
(a)



(b)

Figure 8. Pure and impure separation percent in constant frequencies of 30, 35 Hz at second combination

In graphs of Figure 9, percent of pures and impures separation have compared with each other in a constant slope and the effects of frequency on each percent of separation have been investigated. In Figure (9-a), the highest stigma separation is in frequency of 35 Hz and amplitude 7 μ with an average of 90.63% and impure percent of 23.12%. Considering the above points, in Figure (9-b) the best separation has been performed in frequency of 30 Hz and amplitude 5 μ with an average of 89.75% and percent of impurity 47.68%.



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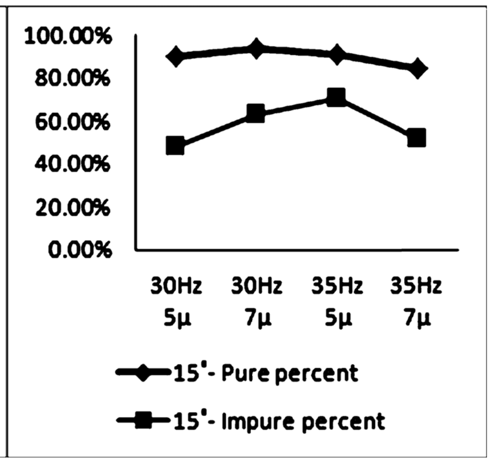


(b)

Figure 9. Pure and impure separation percent in constant slopes of 10˚, 15˚ at second combination

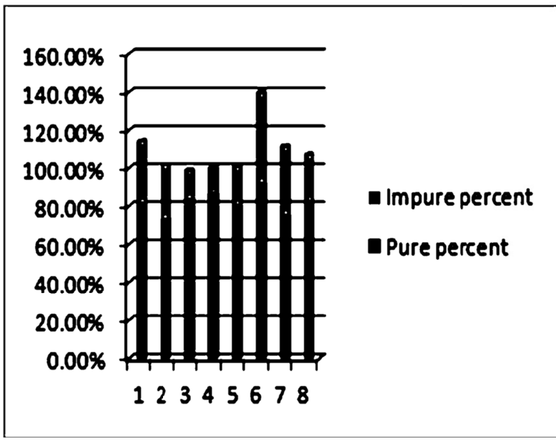
3.3.3 General State of Wind Tunnel-Oscillating Seperator

The mean values for general state is given in Table 10. According to the Table 10, it is khown that the highest stigma mean is related to experiment of 6 with 92.04% stigma separation and the lowest impurities percent is related to experiments of 4 and 3 with 14.14% and 15.45% impurities separation, respectively.

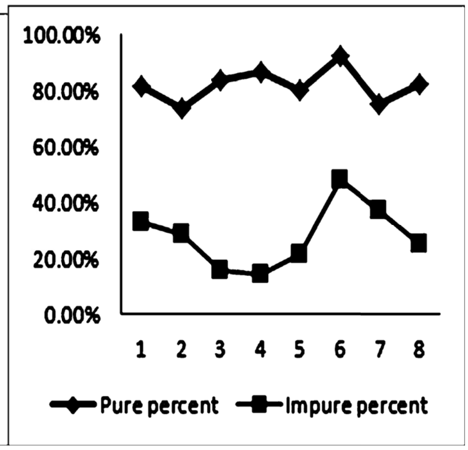
Table 10. Stigma and impurities seperation percent in second general combination

Test No.	Stigma percent	Impurities percent
1	81.58%	33.07%
2	73.53%	28.30%
3	83.74%	15.45%
4	86.29%	14.14%
5	79.97%	21.28%
6	92.04%	48.06%
7	75.01%	36.88%
8	82.08%	25.39%

Stigma and impure separation percent have been shown in Figure (10-a). Maximum separation with minimum impurities has clearly identified in experiments of 3 and 4. In Figure (10-b) by comparing the values of impurities and purities of experiments 3 and 4 can be found that experiment of 4 has the best result because of more total initial sample and low percent of impurities versus the high pure percent. After experiment of 4, experiment of 3 has the best response to stigma separation.



(a)



(b)

Figure 10. Pure and impure separation percent in second general combination

With comparing of 2 general states of experiments, it can found that stigma separation percent in most experiments of second combination is more than first combination, so second combination can be the good state. Combinating the two seperators in one separator device which compromise the vibration with air blowing, will have the good response like these states. In both combinations, frequency of 35 Hz, amplitude 7 μ and slope of 10˚ has the good responses.

4. Conclusion

Based on the present paper following conclusions are drawn:

1) In the wind tunnel, the velocity of air is varied in the range of 1.9-3.5 m/s and 1.9-3.7 m/s respectively at first and second combination.

2) The best response of separation in first and second combination was in the experiment of 4 with frequency of 35 Hz, amplitude 7μ and slope of 10˚.

3) The initial bulk of sample is one of the parameters that affects on separation which we can control it by a valve.

4) If the oscillator plate is changed with a longest one, we can expect the stigma separating to be increased by increasing the time of the separation.

5) Petals can separate in stage of oscillator. Removing the petals can performe by creating obstacles such as a number of thin rods with same distance and parallel that place on the oscillating separator in several rows.

6) The type of feeding is important in seperation, if we change the feeding type or large chute dimensions, that we can expect that Concentration and accumulation of components don't repeat again in wind tunnel.

7) If obstacles against the stigma vibrating is reduced, the separation time decreases with high quality separation.

8) Combinating the two seperators in one separator device which has the vibration frequency of 35 Hz, amplitude 7μ and slope of 10° and air blowing in the range of 1.9-3.7 m/s , will have good response like these states.

9) Output of each seperators has stigmas with stamens, so using electrostatic separation can be effective in separating these two components.

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