First contribute to the mechanization string of saffron flowers (*Croccus Sativus L*)

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Abstract
In this work the some preliminary results of tests to mechanical string of the saffron stigmas in air current are shown. In particular have been compared, three models of air separation which some structural difference: duct diameter, air speed and the separation surface. For the flower disarticulation by cut and three system of cut are compared. The force applied for the cut, was relatively low (0,21 N) if the extraction stigmas by the hand was simulated; but increased if the operating conditions was expecting to simulated the cut reaching values included between the 7,39 N and the 21,37. Between the three cyclone system there was the following differences: a) Cyclone type 1: at the 3,5 m/sec maximum speed, the 49,3% of stigmas underwent the loss of one or two filaments; b) Cyclone type 2: reduction of the 25% of the duct diameter, does not complete the separation; c) Type 3: reduction of the 14% of the duct diameter and speed of the air included between 0,69 m/sec and 1,5 m/sec, the separation is completed (96% of separate stigmas) does not highlight stigmas damage. In definitive, the system arranged with the cyclone of type 3 is able to obtain a high percent of separation of stigmas which constitutes the beginning for the realization of a prototype for the experimentation in full field.

Keywords: saffron, stigmas, mechanical string.

Introduction

Sardinia has the national supremacy of the cultivated surface to saffron (70%) and of the production (80%). Today the separation of stigmas (fig. 1) still took 55% to 66% on the total work time because made exclusively to hand. The mechanization string of the saffron flower, is an important factor because gives an economic opportunity to the farmers to change the saffron cultivation from a secondary income in a primary income, with an increase in the amount of product obtained for hectare. Actually, without this chance stigmas production remains located strongly in an border role which not increase the economic importance of the product (spice).

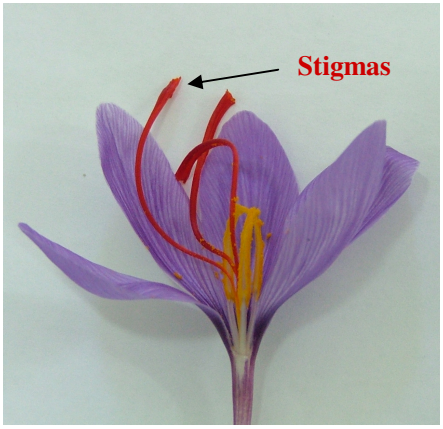

Figure 1. Saffon stigmas

Matherial and method

The study, carried out in laboratory, was the beginning of study at last to arrive to the building of a prototype for the mechanical string of the saffron flower after the separation, by cut, of its components. The cut simulation was made with one texture analyzer (Low Force Plus, LFP, Nexygen, LTd). The dimensional flowers parameters were taken on a sample of 100 flowers with three repetitions, taken accidentally; this taken ones were: the diameters, longitudinal (lt), transversal (t) and intermediate (w), by an electronic caliper model s 225

(Wurth) with resolution of 0,001mm; the average geometrical diameter (Dg); the sphericity (Φ) expressed in per cent; and the superficial area (S) of the three parts of the flower calculate using the Mohsenin (1), (2) and Baryeh (3) formulas. The separation of stigmas was tested and obtained with three different types of cyclone (fig.2, fig. 3 and fig 4), in which we have modified air speed the diameter of the duct and the area of the separation surface. The data of air speed was collected by a thermo anemometer (DO 2003, HVACRI, Salmoiraghi, Inc). All the data, were statistically analysed with the software Statgraphics, XV-Centurion (StatPoint.Inc, 2005) by the analysis of the simple variance (ANOVA).

$$Dg = (LWT)^{1/3} \text{.....(Mohsenin ,1970).....(1)}$$

$$\Phi = \frac{(LWT)^{1/3}}{L} * 100 \text{.....(Mohsenin ,1970)..... .....(2)}$$

$$S = \pi * Dg^{2} \text{..... ...(Bryeh ,2001)..... .....(3)}$$

Figure 2. Cyclone type 1

Figure 4. Cyclone type 3

Figure 3. Cyclone type2

Results and discussion

Cut strength

As was shown in table 1 can be observe that the detachment strength to be applied, assuming an direct work of the farmer finger on the stigmas, was rather low 0,21 N, and this value proves the extreme accuracy which is necessary to proceed at the harvest of saffron stigmas.
The choice to traditional blades which simultaneously cut the flower and stigmas needs the application of strengths included among the 7,39 N and the 21,37 N (0,7 kg and 2,1 kg). Between the groups (table 1) the cut simulated with ferrule to 0,5 mm and with cutter blade showed a low significant difference level, instead the others remaining groups are between them highly different.
Such application, suitable after the harvest, can be arrange the flower parts at the harvest: leaves, petals, anthers and stigmas. These can be separated independently by the use of airflows which remove the other parts not necessary by the differences between the specific weight of the same ones.

Table 1. Comparison between the different cut systems (ferrule, cutter blade and scissor)

Blade utilized	Number of samples (n)	Strength average (N)	Homogenous group
Detachment(1)	25	0.21	X
Cut simulated with ferrule to 0,5 mm (2)	25	21.37	X
Cut simulated with cutter blade(3)	20	15.28	X
Cut simulated with scissor (4)	20	7.39	X
Comparison between groups		significant differences	
2 - 3		*6.0877	
2 - 4		*13.9792	
3 - 4		*7.8915	

Multiple Range Tests, Method: 95.0 Multiple Tests, Method range: 95.0 confidence percent averages were separated with the Duncan Test; Average * reveal a significant statistical difference ($p < 0,05$).
(1)detachment of the stigmas; (2),(3),(4) positioning and cutting of the whole flower.

Dimensional parameters of the saffron flowers in the two experimental fields.

The flowers analyze in the two experimental field (A and B) showed differences for the sites and between the parts petals, anthers and stigmas, (table 2). For the average geometrical diameter of the three parts its varied from 18,36 mm to 21,00 mm for the petals; from 4,04 mm to 4, 98 mm of the anthers and from 2,66 mm to 4,84 mm in the field A and B respectively. Between all these parameters the two most important was the superficial area and the weight of the component. For all the part of the saffron flower harvested in the two fields, there was differences in the superficial area and in the weight. For effect of the variability observed on these two parameters, it was possible therefore to lead the various separation tests and obtain an high or low separation between the components of the flowers. The Superficial area exposed to the air varied from 0.22 mm^2 to the stigmas in field the B and

the 12,82 mm^2 of the petals in field A. The weight of the three parts varied from the 0,01 g to the stigmas in the field B and the 0,05g of the stigmas and the petals in the field A.

Table 2. Average geometrical diameter, sphericity, surface area and weight to the parts of saffron flowers harvest in two experimental fields (A and B)

Experimental field (A and B)	Average geometrical diameter (Dg)	Sphericity (Φ)	Superficial area of the flowers parts exposed to the air (S)	Weight
Petals	(mm)	(%)	(mm^2)	(g)
A	21,00 ± 3,25	50,66 ± 1,14	13,82 ± 0,53	0,05 ± 0,01
B	18,36 ± 1,40	39,92 ± 0,34	10,58 ± 0,22	0,02 ± 0,03
Anthers				
A	4,98 ± 0,58	23,18 ± 1,50	0,78 ±0,17	0,02 ± 0,01
B	4,04 ± 0,72	20,92 ± 0,12	0,51 ±0,11	0,02 ± 0,02
Stigmas				
A	4,84 ± 1,02	10,77 ± 0,09	0,54 ±0,60	0,05 ± 0,02
B	2,66 ± 0,23	9,13 ± 0,13	0,22 ± 0,04	0,01 ± 0,02

Results of the airflow separation of the saffron flowers.

Results obtained with the Cyclone to type 1.

The separation of the various components takes place in conditions of growing speed passing from 0 m/sec at 4,2 m/sec (table 3), limit, beyond which the air speed determines the expulsion also of stigmas.

In consequence of the contact with the grained surface of the metal of which the separation duct is however constituted, some losses of filaments (breaks) of stigmas and the formation of a compact composed floral product mass from stigmas, anthers and petals are determined to the sides of the net of what the fan separates from the duct.

This behavior previously registers the disjointed flowers for effect of the vibrations transmitted by the fan of the wide surface of separation (40 cm) on which are deposited with the scissors from the operators engaged in the test. Experimentations led with speeds included among the 2,5 m/sec, 3,0 m/sec and 3,5m/s, the anthers and the petals of the saffron flower did not separate for expulsion from the duct or produce the break of one or two filaments in consequence of the collisions with the duct borders for the 50% of the saffron stigmas. The operating cyclone capacity ranges from 19,2 g/h to 168,0 g/h if the variability of the weight of the harvest stigmas was considered.

Results obtained with the Cyclone to type 2.

In this type of cyclone the surface of separation was reduced to the 25% of the diameter from 40 cm to 35 cm, and in consideration to the damage produced by the collision with rigid and

grained walls, the metal was replaced with of the pyrex glass to high resistance and smooth walls.

Table 3. Air speed, surface separation, flowers capacity (for minutes and for hour), saffron products and final quality of the stigmas in cyclone type 1

Air speed	Area of separation	Flowers separed	Capacity operating (Co)	Saffron product	Quality of the stigmas after separation		
					Stigmas damage		
(m/s)	(m^2)	(n°/min)	(flowers/h)	(g/h)	thre filaments 50 % (g)	two filaments 37 % (g)	one filament 13 % (g)
2,5	0,12	32	1920	96,0* 19,2**	48,0 9,6	33,6 6,72	17,4 7,1
3,0	0,12	44	2620	131,0* 26,2**	65,5 13,1	45,9 9,2	19,6 3,9
3,5	0,12	56	3360	168,0* 33,6**	84,0 16,8	58,8 11,8	25,2 5,0

**stigmas (weigh 0,05g relate flower weight/weigh stigma; 41% on the total weight)*
*** stigmas (weigh 0,01g relate flower weight/weigh stigma; 20% on the total weight)*

Tests were made to the same conditions of speed of the preceding test passing from 0 m/sec at 4,2 m/sec (table 4). In these operating conditions even if a separation surface reduction was there the operating fan conditions turned out unfit to enliven an amount of sufficient air to separate the three flower components. The petal separation was obtained but the anthers and stigmas remained inside the separation duct. The speed and the door of the air which cross the duct raised of a height equal at 15 cm, 17 cm stigmas and the anthers but a complete separation of the two components was not determined. Ruptures of the stigmas in consequence of the contact with the duct surface were high from 13% to 37% of the filaments was breaking and however determined the formation of a compact mass of floral product composed by stigmas, anthers and petals to the sides of the net of what separates the fan from the duct. The operating cyclone capacity ranges from 18,0 g/h to 153,0 g/h if the variability of the weight of the harvest stigmas was considered. Also in this type of cyclone, this behaviour registers the disjointed flowers for effect of the vibrations transmitted by the fan to the separation surface up which are deposited.

Results obtained with the Cyclone to type 3.
In this type of cyclone the diameter of the duct (surface of separation) was reduced to another 14% from 35 cm to 30 cm and the pyrex glass was replaced by plastic and transparent PVC with smooth walls for a 120 cm height. To increase the speeds of the air inside the duct a snail fan was suitable for the same one while test execution conditions were modified with a speed reduction (about 50% of the other tests) passing from 0,69 m/sec to 1,5 m/sec (table 5).

Table 4. Air speed, surface separation, flowers capacity (for minutes and for hour), saffron products and final quality of the stigmas in cyclone type 2

Air speed	Area of separation	Flowers separed	Capacity operating (Co)	Saffron product	Quality of the stigmas after separation		
					Stigmas damage		
(m/s)	(m^2)	(n°/min)	(flowers/h)	(g/h)	three filaments 50 % (g)	two filaments 37 % (g)	One filament 13 % (g)
2,5	0,09	30	1800	90,0* 18,0**	45,0 9,0	33,3 6,66	11,7 2,3
3,0	0,09	42	2520	126,0* 25,2**	63,0 12,6	46,6 9,3	16,4 3,7
3,5	0,09	51	3060	153,0* 30,6**	76,5 15,4	56,6 11,3	19,9 3,9

**stigmas (weigh 0,05g relate flower weight/weigh stigma; 41% on the total weight)*
*** stigmas (weigh 0,01g relate flower weight/weigh stigma; 20% on the total weight)*

Table 5. Air speed, surface separation, flowers capacity (for minutes and for hour), saffron products and final quality of the stigmas in cyclone type 2

Air speed	Area of separation	Flowers separed	Capacity operating (Co)	Saffron product	Quality of the stigmas after separation		
					Stigmas damage		
(m/s)	(m^2)	(n°/min)	(flowers/h)	(g/h)	three filaments 96 % (g)	two filaments 3,5 % (g)	one filament 0,5 (%) (g)
0,69	0,08	30	1800	90,0* 18,0**	86,4 9,0	3,1 6,6	0,5 2,3
0,92	0,08	36	2160	108,0* 21,6**	103,7 20,7	3,7 0,7	1,2 0,2
1,50	0,08	44	2640	132,0* 26,4**	126,7 25,4	4,6 0,9	0,7 0,1

**stigmas (weigh 0,05g relate flower weight/weigh stigma; 41% on the total weight)*
*** stigmas (weigh 0,01g relate flower weight/weigh stigma; 20% on the total weight)*

In these operating conditions even if a separation surface reduction was there the operating fan conditions turned out suitable for the following reasons:

1) with air speed included between 0,69 m/sec and 0,92 m/sec was separated further on the 96% of stigmas of the 100 flowers with which we began the test and enlivened an amount of sufficient air to separate the three flower components.

2) the petals and anthers separation was obtained and the stigmas remained inside the separation duct floating a an height of about 30 cm to the separation surface and the operating cyclone capacity ranges from 18,0 g/h to 132,0 g/h if the variability of the weight of the harvest stigmas was considered. .

3) damages observed on stigmas were relatively low (stigmas with two or a single filament equal to 3,5% and 0,5% respectively).

4) wasn't determinate in this cyclone the formation of a compact mass of floral product formed by stigmas, anthers and petals inside the duct.

5)vibrations transmitted by the fan to the surface on which the disjointed flowers are deposited did not produce any anthers and petals store to the separation surface borders.

Conclusions

The saffron cultivation, in reason to the observations made and to the results obtained, is susceptible to an rational and effective mechanization which would give the same one a considerable decrease of the production costs. In the short run operations which could benefit from a mechanization level raising are all, except for the harvest and for the flower string. The introduction of the mechanical harvest and string of the flowers is bound to the adjustment, also minimize, the regularity and the dimensions (hectares) of the cultivation farm to allow the harvest machine participation. If for a few agricultural operations it was possible proceed in associated, like that form to increase sensitively the business dimensions, the advantage would be still more tangible. Of safe benefit, for the entrepreneurs engaged in this cultivation, it could be represented by the availability of a reference surface, managed by several producers with the experts' contribution, on which make the cultivation applying the last technologies in order to be compared and be conformed the knowledge. They still remain in to the traditional condition the harvest and the flowers string which are at the present (handmade). Experimental tests on the harvest and flowers string must be stretched connected, because the first must receive some of the technical-operative demands of the second. At last, to attribute at the saffron development an important economic role it is necessary go beyond the traditional method of production, principally harvest and flower string by hand arranging a single experimental project, in order to implement a mechanical system to flower string able to execute the intervention respecting the quality of the final product.

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