Effect of Different Drying Methods on Saffron (*Crocus Sativus L*) Quality

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ABSTRACT: *The substances responsible for saffron's characteristic quality are crocins, picrocrocin, and safranal. The drying process is critical to the saffron quality as measured by levels of secondary metabolites, crocin (color and anti-tumor properties), picrocrocin (taste), and safranal (aroma). Four different dehydration methods were evaluated: Iranian traditional method (room temperature); dehydration with electrical oven at different temperatures; and dehydration with microwave at different powers. The results showed that the highest coloring strength was obtained when saffron treated at higher temperatures and lower times. Also the higher amount of safranal (aroma) and crocin (color) was obtained at high temperature. There was not significant difference between the amounts of picrocrocin at different temperatures in all drying methods. Between these methods, drying with microwave at 1000 W and drying at room temperature obtained the highest the lowest results respectively.*

KEYWORDS: *Saffron, Crocus sativus, Drying temperature, Quantitative analysis, Safranal, Crocin, Picrocrocin.*

INTRODUCTION

Saffron is the dried stigmas of a flower scientifically identified as *Crocus sativus L.* Although the source of saffron is unknown, it apparently originated in the area of Iran, Turkey and Greece, but now it is also successfully cultivated in such European countries as Spain, Italy, France, and Switzerland, as well as in Morocco, Egypt, Israel, Azerbaijan, Pakistan, India, New Zealand, Australia and Japan. While the world's total annual saffron production is estimated to be 190 tons, Iran produces about 90% of the total [1-3]. Saffron is the world's most expensive spice and apart from its traditional value as a food additive recent studies indicated its potential as an anti-cancer agent [4-6].

The stigmas contain carbohydrates, minerals, vitamins and such pigments as carotenes, and flavonoids [7,8]. The bitter-taste is produced by the picrocrocin ($C_{16}H_{26}O_7$), a monoterpene glycoside precursor of safranal ($C_{10}H_{14}O$), the main volatile oil responsible for the aroma. β-Glucosidase action on picrocrocin liberates the aglycone, 4-hydroxy-2,6,6-trimethyl-1-cyclohexene-1-carboxaldehyde (HTCC, $CH_{16}O_2$;MW168), which is then transformed to safranal by dehydration during the drying process of the plant material [9,10]. The color of saffron comes from the water-soluble glycosidic cis- and trans-carotenoids crocins, glucosyl esters of crocetin (8,8′-diapocarotene-8,8′-dioic acid; $C_{20}H_{24}O_4$). For commercial purposes the quality of the coloring power of a saffron sample depends on the quantification of the crocin analogues by colorimetric and some other methods[11].

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The drying methods, applied to reduce the moisture of *C.sativus L.* stigmas to 10-12% and thus produce commercial saffron, toasting (Iran and Spanish), drying at room temperature, sun-drying (India)[12]. From the evidence available there is also much uncertainty about the ideal condition for the drying of saffron. The aim of this work is designed to establish whether significant improvement in the quality of Iranian saffron could be achieved by different drying methods, in particular the use of higher temperatures, and in doing so to further the understanding of the biochemistry of saffron drying.

EXPERIMENTAL SECTION

Collection of material. Full- bloomed flowers were picked by hand from three different farms around Torbathheydariye (Khorasan, Iran) at three different harvest dates of November 13, 18 and 22, 2005. It should be noted, however, that no attempt was made to test for the effect of harvest time in this study and that a variety of factors such as weather condition and the exact time between flower picking and stigma removal would have varied between harvest dates. The flowers were transported and kept in cool condition (4 °C) before treatment. Stigmas for the experiments were separated by hand from flowers at 24 °C indoor.

Saffron dehydration process

In Iranian traditional method, the stigmas (about 20 g of fresh stigmas) were dehydrated by spreading them on a piece of paper at room temperature for four days. The dehydration of samples (5g of fresh stigmas) was carried out at three different powers (200, 600 and 1000 W), using a National Model microwave. In drying with electric oven, 5 g of saffron stigmas were placed in Petri plates and oven at different temperature (55, 65… 85 °C), using a 75 L MEMERT oven. Drying with infrared waves was carried out, using a Shimadzu Electronic Moisture Balancer Model LIBROR EB-340MOC by placing 5g of sample in the instrument pan in each experiment and drying temperatures were fixed at 60, 70 … 110 °C to investigate the effects of drying temperature on saffron quality. All experiments were repeated three times and the tray load was the same in all experiments.

Analytical Determination

Saffron samples were powdered and passed through a 40 Mesh sieve. For determination of pigments, crocins, picrocrocin, and safranal, saffron samples were analyzed following the ISO 3632 standard. Measurements of $E^{1\%}$ of an aqueous saffron extract at 442, 330 and 257 nm were carried out with a 1 cm pathway cell on a Shimadzu UV-Visible 1100 spectrophotometer. Moisture content was also determined according to ISO 3632[13]. ($E^{1\%} = \frac{A \times 2000}{100 - h}$, where: A= absorption, h= moisture%).

RESULTS AND DISCUSSION

Effect of temperature

Analysis of the results confirmed (Table 1 and Table 2) that the lower temperature need longer drying times (4 days at room temperature) therefore a poor quality material would be produced. This is probably due to enzymatic activity, which results in biodegradation of crocin [14]. At higher temperatures processing need considerable less time (treatments D, E, F and M) but thermal degradation of pigment resulted poor quality product . Saffron samples at an optimum temperature of 80-90 °C in infrared drying and 65-75 °C in oven drying, contained the highest amount of crocin after drying (Fig. 1).

Effect of different drying processes on saffron chemical composition

All the drying treatments produced saffron with final moisture content at or below the recommended maximum (12 %) required by the ISO-3632 standard [13]. The total crocin content increased, when saffron sample dehydrated at higher temperature up to 100 °C in infrared drying method and up to 75 ◦C in oven drying (Tables 1 and 2) but at low temperatures (treatments A, and N), and high temperatures (treatments E, and F) the amount of crocin is lower than the others treatments. This is due to probably of thermal degradation in high temperatures or biodegradation in low temperatures [15]. The loss of crocin occurring in the higher temperature treatments would be the result of nonenzymatic thermal degradation, but it would appear that by keeping the high temperature in relatively short time, this loss was minimized and no enzymatic degradation would have occurred and the enzymes were denatured.

Significant increase in the relative safranal contents at high temperatures are most likely due to direct thermal conversion of picrocrocin at these high temperatures

Table 1: Content of main components in saffron after drying processes with infrared waves.

Treatment code	Drying protocols	Drying time (min)	Crocin[a] $E^{1\%}$	Safranal[b] $E^{1\%}$	Picrcrocin[c] $E^{1\%}$
	Infrared drying at (°C)				
A	60	95	156.4	36.2	83.1
B	70	75	213.8	35.3	87.5
C	80	61	224.6	35.8	91.8
D	90	47	226	35.8	90.4
E	100	37	225.3	38.7	93.3
F	110	32	224.7	42.7	93.1

$$E^{\%1} = \frac{A \times 2000}{100 - h}$$

a: $E^{1\%}$(1cm, 442 nm) according to the ISO 3632 standard method.
b: $E^{1\%}$(1cm, 330 nm) according to the ISO 3632 standard method.
c: $E^{1\%}$(1cm, 257 nm) according to the ISO 3632 standard method.

Table 2: Content of main components in saffron after different drying processes.

Treatment code	Drying protocols	Drying time (min)	Crocin[d] $E^{1\%}$	Safranal[e] $E^{1\%}$	Picrocrocin[f] $E^{1\%}$
	Microwave drying at				
G	200 W	12	268.9	28.21	99.1
H	600 W	4.5	260	26.9	97.3
I	1000 W	3.5	268.9	40.9	103.1
	Electronic oven drying at (°C)				
J	55	150	255.5	34	105.1
K	65	115	263.6	34.9	108.4
L	75	80	259.3	32.8	110.7
M	85	50	245.1	33.7	112.2
N	Iranian traditional method	4 days	242.7	30.4	88.4

$$E^{\%1} = \frac{A \times 2000}{100 - h}$$

d: $E^{1\%}$(1cm, 442 nm) according to the ISO 3632 standard method.
e: $E^{1\%}$(1cm, 330 nm) according to the ISO 3632 standard method.
f: $E^{1\%}$(1cm, 257 nm) according to the ISO 3632 standard method.

(100-110 °C in IR drying) as opposed to the enzymatic pathway. The fact that these treatments (D, E, F, K and L) also exhibited equal or significantly better retention of crocin pigment in comparison to the lower temperatures. This indicates that the type of drying would be a means of producing high quality saffron in sense of aroma. However there were not found more safranal in the samples G, H, and K, there were still a significant amount of picrocrocin available for conversion to safranal (Fig. 3). In infrared drying there were not significant differences between picrocrocin content at different treatments but in oven drying at 75-85 ◦C the highest amount of picrocrocin was obtained it is likely due to that at these temperatures enzymes were denatured

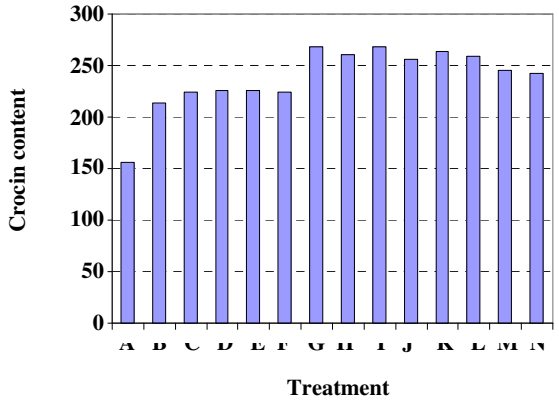

Fig. 1: Comparison of crocin content of different drying treatments.

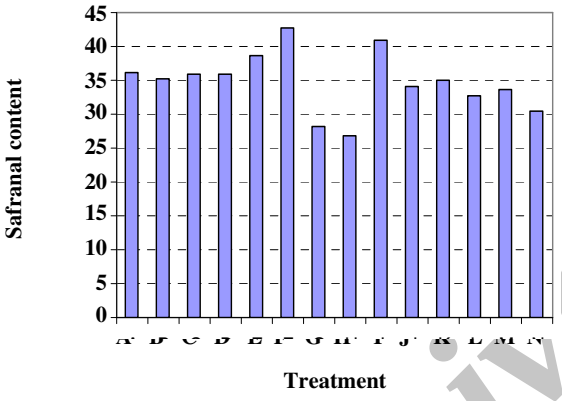

Fig. 2: Comparison of safranal content of different drying treatments.

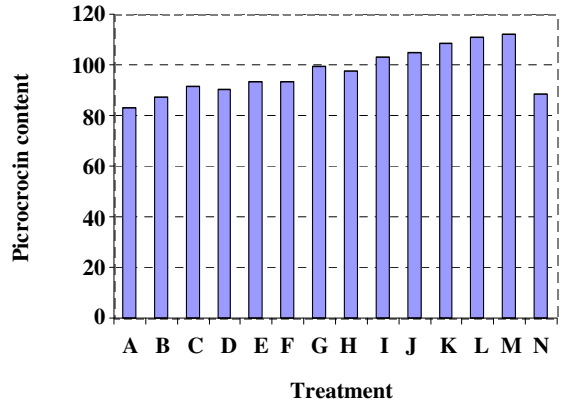

Fig. 3: Comparison of picrocrocin content of different drying treatments.

and there was not enough heat for thermal conversion pathway [16]. Between this methods microwave drying method obtained the best amount of safranal at 1000W (treatment I) and the amount of crocin and picrocrocin were also high. The lowest amounts of safranal were obtained by microwave drying method at 200 and 600W (treatments G, and H) in Fig. 2.

The color and aromatic strength of treatment N (traditional method) were acceptable but the lowest amount of picrocrocin was obtained by this method.

CONCLUSIONS

The results showed that the highest coloring strength was obtained when saffron treated at higher temperatures and lower times. Also the higher amount of safranal (aroma) and crocin (color) was obtained at high temperature. There was not significant difference between the amounts of picrocrocin at different temperatures in all drying methods. Between these methods, drying with microwave at 1000 W and drying at room temperature obtained the highest the lowest results respectively.

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REFERENCES

[1] Fernandez J.A., Biology, Biotechnology and Biomedicine of Saffron, *Recent Research of Development in Plant Science*, **2**, p. 127 (2004).

[2] Negbi M., Saffron Cultivation: Past, Present and Future Prospects. In: M. Negbi (Ed.), "Saffron (*Crocus Sativus L.*)", (pp. 1–17). Amsterdam: Harwood Academic Publishers, (1999).

[3] Xuabin N., Research Progresses on the Saffron Crocus (*Crocus Sativus*), *Zhongcaoyao*, **23**, p. 100 (1992).

[4] Dufresne C., Cormier F., Dorion S., In Vitro Formation of Crocetin Glucosyl Esters by *Crocus Sativus* Callus Extract, *Planta Medica*, **63**, p. 150 (1997).

[5] Escribano J., Alonso G.-L., Coca-Prados M., Fernandez J.-A., Crocin, Safranal and Picrocrocin From Saffron (*Crocus Sativus L.*) Inhibit the Growth of Human Cancer Cells in Vitro, *Cancer Letters*, **100**, p. 23 (1996).

[6] Tarantilis P.A., Polissiou M., Manfait M., Separation of Picrocrocin, Cis-Trans-Crocins and Safranal of Saffron Using High Performance Liquid Chromatography with Photodiode-array Detection, *Journal of Chromatography* **A, 664**, p. 55 (1994).

[7] Abdullaev F.I.,Biological Effects of Saffron. *BioFactors*, **4**, p. 83 (1993).

[8] Winterhalter P., Straubinger M., Saffron-Renewed Interest in an Ancient Spice, *Food Reviews International,* **16**, p. 39 (2000).

[9] Lozano P., Delgado D., Go´mez D., Rubio M., Iborra J.L., A Non-Destructive Method to Determine the Safranal Content of Saffron (*Crocus Sativus L.*) by Supercritical Carbon Dioxide Extraction Combined with High-Performance Liquid Chromatography and Gas Chromatography, *Journal of Biochemical and Biophysical Methods*, **43**, p. 367 (2000).

[10] Sujata V., Ravishankar G.A., Venkataraman L.V., Methods for the Analysis of the Saffron Metabolites Crocin, Crocetin, Picrocrocin and Safranal for the Determination of the Quality of Spice Using Thin Layer Chromatography, HPLC and GC., *Journal of Chromatography* **A,624**, p. 497 (1992).

[11] Li N., Lin G., Kwan Y.W., Min Z.D., Simultaneous Quantification of Five Major Biologically Active Ingredients of Saffron by High-Performance Liquid Chromatography. *Journal of Chromatography* **A, 849**, p. 349 (1999).

[12] Rania B.L., Agarwal G.S., Bhata A.K., Guar G.S., Changes in Pigments and Volatiles of Saffron (*Crocus Sativus L.*) During Processing and Storage, *J. Sci. food Agric,* **71**, p. 27 (1996).

[13] International Standard, "Saffron-Specification", ISO 3632- 1:1993(E), International Organization for Standardization, Switzerland, (1993).

[14] Bansi L Raina, shiri G Agarwal, Ashok K Bhatia and Govind S. Gaur, Change in Pigment and Volatile of Saffron (*Crocus Sativus L.*) During Processing and Storage, *J Sci Agric*, **71**, p. 27 (1996).

[15] Wlazly A., Targonski Z., Polyphenoloxidase and β-Glucosidases in Selected Berry Fruits, *Zyenosc* , **7**, p. 122 (2000).

[16] Manual Carona, Amaya Zalacain, Jose Emilio Pardo & Gonzalo Luis Alonso, Influence of Different Drying Method and Aging Condition on Saffron Constituents, *J. Agric. food chem.,* **53**, p. 3974 (2005).