Study of Chemical and Microbiological Properties of Saffron Dehydrated by using Solar Drying System

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Abstract- Saffron is the most expensive spice and is highly valuable for non-oil export. Drying process is a critical control point with major effects on chemical and microbiological characteristics, so an appropriate drying method shall meet standard and market requirements as well as cost benefit. Different methods include traditional, freeze, solar, vacuum oven and microwave drying. Solar drying is performed in direct or indirect way. In the 1st way, sunlight is directly exposured with product chamber, while in the later, sun light is stored in solar collectors and then warm air flow is pumped to product chamber. Results by spectroscopy for colour agent (Crocin), odour agent (Saffranal) and flavour agent (Picrocrocin) indicated that solar drying represents high values. Moisture content taken as a key factor of dehydration was detected below permitted standard level. Microbiological profile in solar drying was in compliance with standard and in acceptable level. Optimum drying condition was achieved for 6-6.5 hours in 35-45^{o}C. Since all microbial safety and chemical quality properties of saffron are preserved in solar drying and also considering energy saving and the resulted cost benefit of this system, it could be introduced as an appropriate drying method in producing rural and collecting sites of saffron.

Keywords- Solar energy drying; saffron dehydration; safety; quality

1. Introduction

1.1. Saffron Dehydration

Saffron spice is the dehydrated stigmas of Crocus sativus L. During the dehydration process, the stigmas lose around 80% of their weight. Drying leads into the physical, biochemical, and chemical changes necessary to obtain the required properties of saffron. By the way, it helps to preserve the spice [1, 7]. Low quality arises from poor post-harvest processes including drying process which is considered as a CCP, i.e. Critical Control Point. Convenient drying usually is performed for a long time in which enzymatic activity is high and microbial pollution occurs [2].

The six main producer countries employ three different procedures depending on the temperature used; sundried or at room temperature in air ventilated conditions (India, Iran and Morocco), mild temperature by drying slowly in a darkened room at 30-35 C (Greece and Italy) and high temperature by toasting over hot ashes (Spain), Of these, the Spanish methods have been regarded as producing the best quality of saffron. The dehydration process affects the content of compounds participating in saffron colour, taste and aroma [1, 3]. Inappropriate drying may result in scabbing and hardening of the surface, wrinkling, lowering of rehydration, browning, surface burning, decrease in flavour and odour and Millard reaction [4]. The main compounds of saffron are as follows shown in fig 1. A wide family of carotenoid glycosides having the crocetin structure ($C_{20}H_{24}O_4$) which are responsible for colour, the glycoside terpenoid named picrocrocin and some related compounds ($C_{16}H_{26}O_7$), a flavour agent and a large family of terpenic aldehydes and ketones from which safranal is the most representative

($C_{10}H_{14}O$), an odour agent [1,5]. Saffron odour is obtained during drying process by

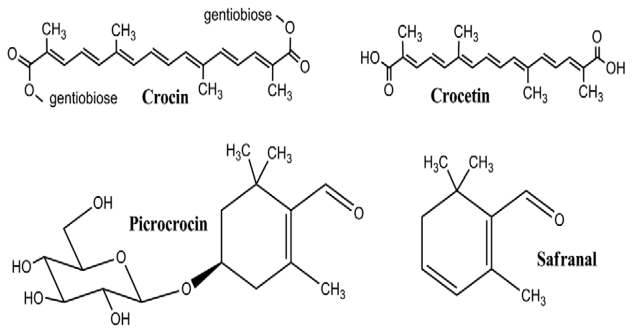

Fig. 1. Structure of the main chemical constituents found in saffron spice [15]

hydrolysis of picrocrocin to volatile safranal. By the way, coloring strength of saffron increases when reduction of moisture content during drying results in hydrolysis of crocin pigment [6]. Lower moisture about 12% according to ISO 3632-2 (2003) preserves quality characteristics of product during longer storage periods [7].

1.2. Solar Drying

Solar drying is performed in direct or indirect procedure. In direct system, sunlight and temperature are directly contacted with product chamber through a clear cover. The reactions are increasing of temperature, moisture exhaust and exit by air flow. In indirect system, there are sunlight collecting sheet, blower pump, drying chamber, side heating system and energy saving system. Main factors in designing such systems could be environment moisture and temperature, air flow rate, relative moisture and temperature of drier, initial and final moisture of product, length and width of air tunnel, height of bed, space and kind of trays and a.w (water activity) of materials. Sun light is stored in solar collectors and then warm air flow is pumped to product chamber [8, 12, 13,17]. If a product is dried over "critical moisture content" quality will be defected dramatically, however insufficient procedure will result in microbial and chemical spoilage [9].

Solar drying has been performed on rice in which temperature was 22.3-34.9 oC, relative humidity 34.5-57.9% and air flow rate 0.2-1.4 m/s [10]. In 2003, Ghazanfari et al., solar dried pistachio in 36 hours, where final moisture of product reaches to 6% i.e. 1% under recommended limit. Maximum temperature of sun light collecting sheet was 56 oC that was 20 oC more than environment temperature [11].

2. Materials & Methods

An amount of about 25gr saffron stigma was selected randomly from collected samples of saffron flowers which were harvested in Ghaen area, one the most important region for saffron cultivation. Then prepared sample was dried in a solar dryer system for 6-6.5 hours at 35-45 ^{o}C.

A solar dryer was designed for the purpose of this study as shown in fig 2. Climatic conditions such as temperature, humidity and solar intensity and nature of the product were some major factors in designing. Multi shelf cabinet dryer was constructed and coupled with flat plate solar air heater for air heating. An air collector with air inlet was considered to collect and store the thermal energy of sunlight. Hot air is supplied through related pipe at the bottom of drying chamber and air moved upward through wire mesh of the shelves. This led into having a warm air flow with a controllable temperature by a heat exchanger. The air flow reached to product chamber containing food drying trays and contact with the product. Finally the air will be exhausted from above the chamber. The dried sample was instantly transferred to laboratory for microbial and chemical tests. The solar dryer was also settled just near to laboratory towards sunlight and wind in summer season with acceptable sunlight during the day.

Major components of saffron; crocin, picrocrocin and safranal in dried samples were quantified by specter-photometric method according to ISO 3632 and Iranian Standard, ISIRI 259-2 at the wave lengths 440, 257 and 330 nm respectively.

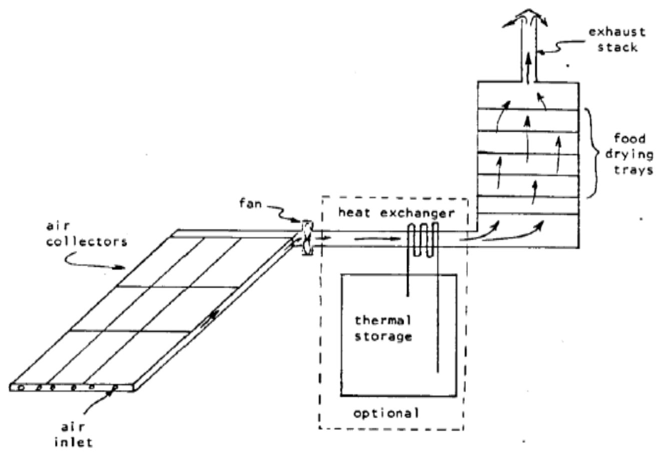

Fig. 2. Schematic plan of the indirect solar dryer

Also moisture content was determined since it poses a significant role in the quality of the dried product. Microbial counts for total counts by plate count agar culture, coliforms and e.coli VRBA and BGBB medium, and yeast and mold by YGC agar culture were performed according to ISO 3632 and ISIRI 356, 437, 997 and 2946. All experiments were carried out in duplicate and data were analyzed by SPSS software.

3. Results & Discussion

Results of moisture content and main quality compounds of saffron after drying are represented in table 1. Results of microbiological safety factors of saffron after drying are shown in table 2.

In this study by using an indirect solar dryer system according to table 1, it was shown that drying of saffron in such system will maintain the moisture content below the recommended upper limit in ISO 3632 which is mentioned to be 12% [16].

Also results of crocin, picrocrocin and safranal shows that solar drying represents better outcome ($p \leq 0.05$) than convenient processes in comparison with the findings of Mazloumi et.al. [6]. As it is represented in table 2, results of microbiological experiments for total microbial count, coliform bacteria and mold count are all below standard permitted limits.

No e.coli bacteria was detected, which its presence could be representative of fecal pollution and poor hygiene of workers especially in their hands while handling the saffron flower. High content of coliform in fresh stigma could be due to using of animal muck.

Table 1. Percentage of moisture and main compounds of saffron (mg/kg) in Solar drying system

Moisture	5.170 ±0.36
Crocin	248.06 ±4.17
Picrocrocin	97.385 ±0.95
Safranal	34.995±0.51

Table 2. Microbiological counts (cfu/mg) of saffron by solar drying

	Solar drying	**Standard Limits**
Total count	$3\times10^3 \pm 10^3$	5×10^4
Coliform	$5\times10^2 \pm 20$	10^3
e.coli	Negative	Negative
Yeast	Negative	5×10^3
Mold	50 ± 7	5×10^3

However fresh stigma were contaminated with e.coli, but after drying it was negative which is in accordance with findings of current study [7]. Yeast count was negative too, far below what permitted in standard [16].

So, these results express that safety and quality requirements of dried saffron are completely fulfilled by the solar dryer system and are in compliance with the findings of Raina et al., in which optimum temperature of solar dryer for saffron was 34-45 oC in 6.3 hours [12]. In another study, it was announced that the temperature of 50 oC could provide better results [13]. In current study temperature of 35-45 oC for 6-6.5 hours was implemented. Indeed, higher temperature requires lower duration, which could be discussed in further research.

In a European research project on saffron, no salmonella bacteria were found, while e.coli bacteria were seen in 5 samples. Enterobacteriacea was present in 79% of samples which most of them had environmental origin. Molds were found in 77% of samples, however in low content [14]. These findings could show the importance of solar drying process in reducing the microbial hazards and its role in preservation of the product, since in current study no counts for e.coli and yeast were detected.

4. Conclusion

According to findings of current study, it can be said that by application of a solar dryer system such as one mentioned here, the desired chemical quality and microbiological safety properties of saffron could be achieved. Solar dryer can be used for improving the chemical compound profile of saffron including crocin, picrocrocin and saffranal which are responsible for color, taste and odor respectively during drying procedure. Also preservation of the product by properly drying and reducing the microbial load could be as another significant achievement. On the other hand, considering energy saving and the resulted cost benefit; it could be introduced as an appropriate drying system in producing rural and collecting sites of saffron.

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