Saffron: on the Contribution of Colorants to its Commercial Quality

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In most national, federal or international legislative documents saffron is reported as a spice having colouring strength. Saffron is traded in the form of whole or cut threads (stigmas plus part of the style) or as powder. Different commercial grades are found in the various countries, some of them distinguished for their exquisite organoleptic characteristics. The International Organisation for Standardisation (ISO) had issued a specific standard for saffron ISO 3632 in 1975, which was revised in 1980 and then technically improved in 1993. In ISO 3632 1&2 (1993) trade standard definitions as well as requirements for saffron quality and methods of analysis are given. One of the quality parameters reported therein is the colouring strength of the aqueous extract of the spice, which is mainly due to the crocin content, as measured spectrometrically at about 440 nm. The classification of saffron into commercial categories relies heavily on the colorant content of the spice. Colorant content depends not only on genetic material but also on factors such as processing, decontamination procedure and storage conditions of the final product.

Drying brings about the physical, biochemical and chemical changes necessary for imparting the desired attributes to saffron. Drying is a difficult task because crocins are water-soluble and consequently washing is prohibited though foreign matter (dust, mud, parts of insects, etc) is not rare. On the other hand, crocins, as all carotenoids, are light sensitive and heat labile so that exposure to light or heat throughout processing should be the minimum. The practice of growers differs among countries as a result of experience gained over the years through trial and error. Each one of saffron growing regions or countries has devised a procedure that takes into account the available resources. Variations in processing are found even among the producers of the neighbouring plots of a certain area.

Spices may be highly contaminated with moulds, yeasts and bacteria, either as vegetative cells or spores coming from plants, soil, or the faeces of birds, rodents, insects, etc. Control of contamination occurring during harvesting, handling, transportation or storage of the spices (Sjöberg et al., 1991) may have a consequence on the colouring potential of saffron. Thus, a substantial decrease (ca. 90%) in the crocins content of irradiated stigmas of saffron and a concomitant increase in crocetin level is reported possibly due to a cleavage in the glucosidic linkages that may occur during irradiation and that gave rise to a twofold increase in the crocetin content whereas the loss in crocin content was 83-89%. Therefore, where permitted, the irradiation doses for this spice should not overcome 5 kGy and also decontamination should be applied to saffron only in cases of low microbial load.

Storability of saffron is not well appreciated by producers, whole-salespersons or retailers. Saffron, as the other herbs and spices, is an intermediate to low moisture content food item that is prone to changes in the relative humidity of the environment. Saffron is produced annually and the safest way is to be sold within the year of harvest. Considering that harvesting (October-November), processing and sorting takes approximately 2-3 months and that balance in the flavour compounds occurs some time after processing,

* [The oral presentation was based on material included in the chapter "Saffron Quality: Effect of Agricultural Practices, Processing and Storage" in *Production Practices and Quality Assessment of Food Crops*, vol. 1 Preharvest practice, Dris, R. and Jain, S.M. (eds.), Kluwer, Dordrecht, The Netherlands, 2004, ISBN 1-4020-1702-2]

transactions are expected to start from March onwards. It is urgent for each region to standardise the best time to start with selling as the customers decision rely mainly on the sensory characteristics of the product. Proper packaging could be the answer but it is well known that most of the world-wide produced saffron is transported in bulk quantities, in carton boxes, bags or tin boxes without a continuous control of the humidity and the temperature of the environment. Although the literature on the stability of carotenoids is substantial (Britton, 1992; Rodríguez-Amaya, 1993) there is little information on the effect of storage on crocins. Depending on molecular structure carotenoid stability is affected by light, oxygen, moisture content/water activity temperature, metals and other pro-oxidants, presence of antioxidants, free radical inhibitors and the composition and physical structure of the sample. Mannino and Amelotti (1977) attempted to examine the optimum storage conditions of saffron.

The results indicated that colour stability was greater at low relative humidity values (5-23%) and low temperatures. Alonso et al. (1990) studied the kinetics of pigments and picrocrocin at 40 ^{o}C and 75% air relative humidity. Under those conditions saffron pigments bleached out within 70 days of storage whereas the bitterness loss was more than 40%. The study was carried out at pH values (3, 5, 7) in O_2 and N_2 atmosphere. Crocin degradation was faster at low pHs in a way similar to that reported for annato extracts. Stability studies at different temperatures showed that storage at 4 ^{o}C (pH 7) reduced degradation rate by a factor of more than 3, 8 and 10 (25, 40 and 62 ^{o}C, respectively). Drying at 40 ^{o}C, representing a common condition of traditional saffron treatment had an equally critical effect to that of light. N_2 atmosphere did not protect significantly the pigments in the aqueous environment. In the presence of other additives colour degradation is sometimes dramatic. Knewstubb and Henry (1988) mention that sulphur dioxide at levels of 50 ppm and above causes bleaching of crocin coloured products and that a degree of protection can be afforded by the use of ascorbic acid. Orfanou and Tsimidou (1995) examined the effect of ascorbic acid on the stability of aqueous saffron extract (40 ^{o}C, pH 5) and found that it was effective only in combination with ethylenediamine tetracetic acid (EDTA). The % colour retention of the extract was three times higher after the addition of an ascorbic acid: EDTA solution, 1:1, w/w. Ascorbic acid itself imparted an adverse effect on colour. An adverse effect on colour retention was also reported for different pHs in the presence of preservatives. Morimoto et al. (1994) studied the stability of carotenoid glucosides in saffron under various conditions. The investigators were interested only in the preservation of crocins, so that the conditions of storage they propose were low temperature, low humidity and possibly nitrogen atmosphere. The results of the storage tests carried out by Raina et al (1996) confirmed our observation that saffron should be used within the year of production. Taking for granted that light should be excluded during storage of saffron, Tsimidou and Biliaderis (1997) carried out kinetic studies on carotenoid loss and changes in other quality attributes at T: 25, 40 and 60^{o}C, a_w: 0.11, 0.23, 0.33, 0.43, 0.53, 0.64, 0.75. Calculation of half-life periods (1st order kinetics) gave useful information for saffron storability. Colour power retained better at lower T and a_w<0.43 Crocin degradation rate increased within the range a_w: 0.11-0.64. An unexpected behaviour was observed at a_w: 0.64 that concur with current concepts on the mobility of reactants in foods. Aroma evolution was favoured at intermediate aw values, so that if saffron is traded as a spice aw values of 0.33-0.43 and not very low temperatures should be used. Storage in a refrigerator, as suggested by Morimoto et al. (1994), and low a_w is correct if only crocin retention is of interest. Selim et al. (2000) presented the first attempt of increasing storability of saffron carotenoids by encapsulation in amorphous polymer matrices such as pullulan, PVP40 and 360, which were selected for their good water solubility and ability to form an amorphous state on dehydration. Encapsulated saffron carotenoids using freeze-drying were studied under unfavourable a_w values (0.43-0.75). PVP 40 had the better protection effect because it collapses rapidly in storage and becomes an effective barrier to oxygen permeation. The half-life periods in relation to control samples increased 4, 18, 7.5 and 7.7 times at a_ws 0.43, 0.53, 0.64 and 0.75, respectively. The unexpected behaviour at a_w 0.64 was reconfirmed. More attention has to be given to the effect of processing and storage on the colour, bitterness and aroma of the product. Conditions that favour colour retention do not necessarily coincide with the optimum conditions for the other two attributes. Commercial quality and, consequently, colorant content can be easily affected by uncontrolled a_w and temperature conditions.

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