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ANALYSIS OF THE ALTERATIONS IN THE COLOR OF PEARS DRIED UNDER DIFFERENT SYSTEMS

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Abstract: In Portugal, pears are traditionally dried by a direct sun-exposure method. However, because of the disadvantages associated with this procedure, alternative dryings are being tested. The objectives of this study were to evaluate how drying influences the color of pears, and to compare the products dried through different systems, to evaluate which one allows obtaining a product as much as possible with the same color of the traditional pears. From the results obtained it was possible to verify that drying in systems with exposure to the sun (through glass) allow obtaining products that do not differ much from the traditional dried pears.

Keywords: pear color, dried pear, solar drying, tunnel drying, color space

INTRODUCTION

One of the fundamental properties of fruits is undoubtedly their color, given that it has been widely demonstrated that this property directly correlates with other physical, chemical and sensorial attributes of product quality (Abdullah et al., 2001). In fact, color plays a major role in the assessment of external quality in food industries and food engineering research. The measure of the standard color of foods can be done by using a multiplicity of color spaces. However, the Hunter Lab color space and more recently the $L^*a^*b^*$ system (CIELab) are the more frequently used color spaces for quantification of color in foods (Mendoza et al., 2006). In the Hunter color space, the dimension L represents lightness, varying from black (0) to white (100) and a and b represent the color-opponent dimensions, with a varying from green ($-a$) to red ($+a$) and b varying from blue ($-b$) to yellow ($+b$).

Drying is one of the methods which has been used since immemorial times for preserving foods, based on the removal of water to a level that minimizes microbial spoilage and deterioration reactions.

In Portugal, pears of the variety S. Bartolomeu are traditionally dried by a direct sun-exposure method. The pears are harvested in August; they are peeled and put to dry whole, without cutting. They are left at open air sun exposure for 5 to 7 days, usually in fields, over straw or nets (first drying). Then they are taken out of the sun and left for about 2 days baffled in barrels covered with blankets, in basements. After that they are pressed, so that their shape changes from round to flat, and they are again put to dry (second drying) at direct open-air sun drying for more 3 to 5 days (Guiné and Castro, 2002).

However, because of the disadvantages associated with this procedure, including not guarantying the sanitary quality and safety of the final product, in the past years alternative drying methodologies have been developed to dry this particular product, such as solar stoves, solar driers or drying tunnels with air heated through a solar collector. These alternative methods intend to take advantage of the cheapness of the energy source (the sun), but protecting the fruits from the external agents such as dust, birds, rats, or even climatic adverse conditions.

The objective of this study was, on one hand, to evaluate how the drying operation influences the color of the pears, and, on the other hand, to compare the color of the products dried through the different systems, in order to find out which one allows the obtaining of a product as much as possible with the same color of the traditional pears, since this is one of the critical factors affecting this product's quality.

EXPERIMENTAL

In the present work pears of the variety S. Bartolomeu were dried under different systems. In all cases the pears were dried until a final moisture content of about 20 % wet basis, for being considered a safe moisture content in terms of conservation characteristics and also because it corresponds to the final moisture of the pears dried by the traditional method, which is considered the reference (Guiné, 2005).

The different drying systems are:

(I) Traditional: the traditional open-air sun drying, following the steps described earlier (Fig. 1);

Fig. 1. Traditional drying

(II) ESAV solar greenhouse: the solar greenhouse used in this study is small (3.2 m long, 1.9 m wide, 2.0 m high in the center and 1.3 m high at the sides), and consists of an aluminum structure with 3 mm greenhouse glass. It has a door and two roof windows, and has coupled a ventilator which was operated in the present experiments at the maximum rotating speed of 1700 rotation per minute, corresponding to the extraction of 900 m3/h of air (Guiné et al, 2007). The drying of pears took place over four tray tables placed inside the drier. These structures were made of wood with 0.5 m high and 1.5 m^2 in area (1.5 m long x 0.6 m wide), over which a nylon net was fixed (Fig. 2). The pears were dried in the stove in two ways: direct exposure and covered not to receive the direct sun rays;

Fig. 2. Solar greenhouse (ESAV)

(III) ESAV stove: an electrical stove WTB Binder with ventilation. The stove was operated at constant temperatures of 30 ºC and 40 ºC, and the air flow was 300 m^3/h;

(IV) ESTV solar: a solar drier developed specifically for the drying of pears, made of glass with different levels, designed for a more efficient use of the solar energy (Fig. 3). The drier was 1 m high and had 5 steps of drying, each 1 m long and 20 cm wide. The backside of the steps was covered with a material with a good reflecting capacity, so as improve the concentration of the energy from the sun into the drying steps. The weight, temperature and air velocity were measured continuously in different points of the drier, and transmitted to a computer. The drier had an entrance at the bottom for air admission, with variable flow, and a campanula at the top for air expelling;

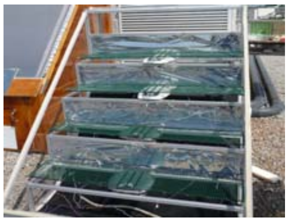

Fig. 3. Solar drier (ESTV)

(V) UC drying tunnel: a drying tunnel, consisting of a chamber with 1 m long and 50 by 50 cm section (Fig. 4a). The air was heated by a solar collector, placed outside, to take advantage of the solar energy (Fig. 4b). The temperature inside the tunnel was kept constant at 40-42 ºC and the drying air velocity was always 1.1 m/s. These properties were measured continuously and registered in a computer.

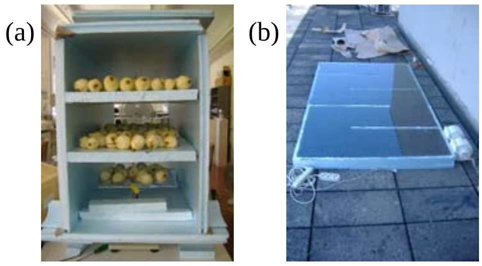

Fig. 4. Drying tunnel (a) and solar collector (b)

The color of the pears dried under the different operating conditions and using the different systems described above was evaluated using a colorimeter (Minolta) in the Hunter Lab color space (Fig. 5). For each set of pears 28 color measurements were made, corresponding to 28 different pears, and the medium value and standard deviation then were calculated.

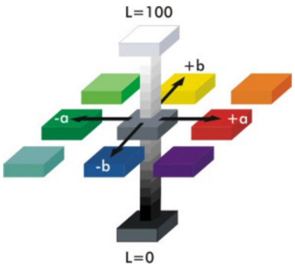

Fig. 5. Hunter Lab color space

RESULTS AND DISCUSSION

Fig. 6 shows pears in different stages of drying using the traditional system, some that have been put to dry only a few hours before and others that have been drying for about 7 days and therefore are at the end of the first drying phase. As it can be seen in the figure, the pears change their color during drying from a light beige color to a pronounced brownish-reddish color. This characteristic color is a very important quality attribute of this traditional food product, and therefore its development is of the utmost importance. For this reason, the alternative drying methodologies are supposed to give products with a color as much similar as possible as the one of the traditional product.

Fig. 6. Pears in different stages of the traditional solar drying

The development of this brownish color may be due to oxidation, Mailhard reactions and enzymatic browning, and these phenomena should also take place in the different dryings tested, so as to produce similar dried pears.

Fig. 7 shows the variation of the color parameters of the pears along time for the drying carried out in the ESAV solar stove (II). As it can be seen, the value of *L* (lightness) decreases from 74 to 33, showing that the pears become very much darker with drying. The value of *a* increases from -4 to 23, revealing that a very slight green tone evolves to an intense red tone. The parameter *b* practically does not change with drying, just varying from 18 at the beginning to 15 at the end, revealing that drying induces just a very slight diminish in the yellow intensity. The conjugation of the intense red with the darkness associated to the *L* parameter, gives place to a reddish-brown color in the dried pears.

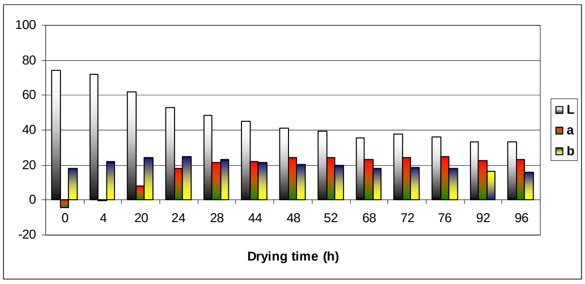

Fig. 7. Variation of color along drying for the ESAV solar stove

Fig. 8 shows the values of the lightness (*L*) for pears dried under different drying conditions and with different systems: traditional solar drying (I), solar stove with pears at direct exposure to the sun and also covered not to receive the sun rays (II), electrical stove at 30 ºC and at 40 ºC (III) (in this system the pears are not exposed to the sun), solar drier (IV) and drying tunnel with air heated by a solar collector (V) (in this system the pears are also not exposed to the sun). The pears dried in the traditional system present a medium value for lightness of 26, which means that these pears are quite dark. As said previously, the traditional pears function as the reference, since what is aimed is to produce pears with approximately the same color as these traditional ones. From the results in Fig. 8, it can bee seen that the pears dried with direct sun exposure (systems II not covered and IV) present the values of lightness that are more similar to the traditional pears (*L* = 33 and *L* = 35, respectively). However, even being these two the systems that give the pears more similar to the reference, the values of *L* for these two alternative systems are still higher that the traditional, indicating that the pears obtained in this way are slightly clearer than the reference. The other systems all give pears much clearer: *L* = 44 for the UC drying tunnel, *L* = 44 for the ESAV electrical stove at 30 ºC, *L* = 46 for the ESAV solar stove covered, *L* = 56 for the ESAV electrical stove at 40 ºC, this last particularly clear, and really much different from the intended lightness for the pears.

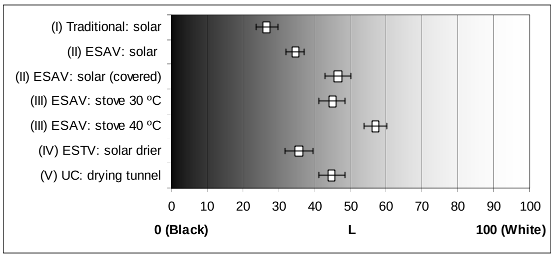

Fig. 8. Values of the color dimension *L* for different dried pears (the error bars stand for standard deviation)

Fig. 9 shows the values of the color parameter *a* for pears dried under the different drying conditions as previously stated. This parameter is also very important for the evaluation of the color of the pears, since it refers to the reddish intensity of the color. The traditional pears show a value of *a* around 20, and once again the two systems which provide a direct exposure to the sun rays are the ones that give pears with values of *a* more similar to the reference: *a* = 23 for both ESAV solar stove and ESTV solar drier. The other systems give pears with less intense red color, with values of *a* equal to 15, 13, 11 and 7, respectively for ESAV solar stove covered, UC drying tunnel, ESAV electrical stove at 30 ºC and ESAV electrical stove at 40 ºC. Once again, the electrical stove operated at 40 ºC, is the system that gives the product which less resembles the traditional pears.

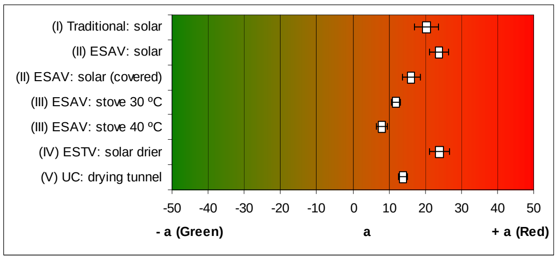

Fig. 9. Values of the color dimension *a* for different dried pears (the error bars stand for standard deviation)

Fig. 10 shows the values of the color parameter *b* for the pears dried under the conditions previously described. As seen before in Fig. 7, this parameter does not seem to present the same level of importance in the definition of the color of the pears as *L* and *a*, since the drying does not produce an important change in the value of *b* from the fresh to the dried state. The traditional pears show a value of *b* around 12, corresponding to a slight yellow intensity. With respect to this parameter, once more the two systems which provide the direct sun exposure are those that give the values of *b* more close to the reference: *b* = 16 for ESAV solar stove and *b* = 17 for ESTV solar drier. The other systems give pears with a slight more intense yellow color, with values of *b* equal to 18 for UC drying tunnel and also for ESAV electrical stove at 30 ºC, *b* = 19 for ESAV solar stove covered, and *b* = 20 for ESAV electrical stove at 40 ºC. Once more, the electrical stove at 40 ºC, is the system that gives the product more different than the traditional pears.

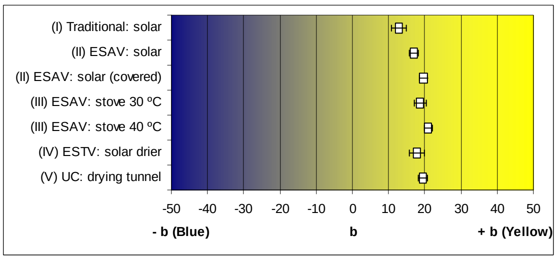

Fig. 10. Values of the color dimension *b* for different dried pears (the error bars stand for standard deviation)

Fig. 11 shows the variation of the color parameters *L*, *a* and *b* in two consecutive years, for different drying systems: traditional drying, ESAV solar stove, ESTV solar drier and UC drying tunnel.

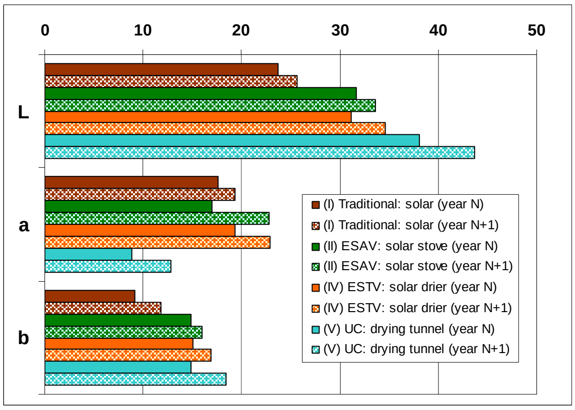

Fig. 11. Color parameters for pears dried in different systems and in different years

The results in Fig. 11 reveal that for all drying systems the values of *L* are higher in the second year (N+1) when compared with the first year (N). Also the values of *a* and *b* show the same trend. This means that in year N+1 the pears were lighter, more red and more yellow, for all drying systems, including the pears dried by the traditional method. Furthermore, the observation that the two systems which originate dried pears more similar to the traditional ones are those which promote a direct exposure to the sun (ESAV solar stove and ESTV solar drier) is confirmed in two consecutive observation years.

CONCLUSIONS

The present work allowed to conclude that is possible to produce dried pears with a color similar to that of the traditional product, using alternative drying methodologies which are better in guarantying the sanitary quality of the product and more efficient in what concerns productivity. However, these alternative systems must still be based on a solar exposure (although not direct) since it was found that those methodologies which do not provide a sun exposure will produce dried pears with different color characteristics than those of the traditional drying.

The dryings carried out in the solar drier and in the solar stove are particularly advisable in order to obtain the desired color. Furthermore, since the fruits are protected inside the glass, they are not exposed to the potential contaminating agents and are also protected from adverse atmospheric conditions, thus allowing to proceed drying even under less favorable atmospheric conditions, without product loss due to rain or night moist. This conclusion is very important for the modernization of the production of this regional food product.

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