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Effect of Abrasive Pretreatment on Hot Dried Goji Berry

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Goji (*Lycium barbarum* L.) is a *Solanaceous* deciduous shrub that grows in China, Tibet and other parts of Asia. Nowadays, goji berries are known as being very rich in nutrients with high antioxidant capacity, fact for which they were included in the novel category of "superfruits". Goji berries contain high amounts of antioxidants, carotenoids, vitamin A and zeaxanthin. Most of goji berries produced are dried because they are very delicate fruits. Drying process improves fruit stability, since it decreases considerably the water activity of the food, reduces microbiological and enzymatic activity and minimizes physical and chemical reactions during storage. However, drying of goji berries can be difficult due to the wax layer surrounding the fruit and the health properties may be reduced by long exposure to high temperatures.
In this study, a physical wax abrasive pretreatment was used to carefully remove the wax layer and reduce drying time. The abrasion of the goji peel was carried out in a motorized drum lined inside with sandpaper. The rotating time was optimized to reduce the damage to the fruits. The drying characteristics of pretreated and untreated fruits were studied using a convective oven at 60 °C and air velocity of 2.1 m/s.
The drying kinetics and fruit quality parameters such as colour, sugars and antioxidant activity were evaluated before and after drying. The results showed that the dried fruit were obtained in less time when they were pretreated (from 21 h for untreated samples to 15 h for pretreated samples), preserving better the colour, increasing the antioxidant activity and maintaining the same sugar content with respect to the untreated case.

1. Introduction

The fruit and root bark of *Lycium barbarum* L. (Solanaceae) have been used in Chinese traditional medicine for centuries. The fruits are commonly known as goji berries or wolfberries.
The original area of Lycium spp. is not definitively established, but is likely found in the Mediterranean Basin. Meanwhile, the plant is widely distributed in warm regions of the world, in particular, in the Mediterranean area and Southwest and Central Asia. It is also cultivated in North America and Australia as a hedge plant (Potterat, 2010). The goji fruit market today is significantly expanding; China, the main supplier of goji products in the world, had total exports generating US$ 120 million in 2010. This production derived from 82,000 ha cultivated nationwide, yielding 95,000 t of wolfberries (Amagase and Farnsworth, 2011). The interest in the composition of goji fruit has intensified because of an increased awareness of their possible health benefits, as they are rich sources of micronutrients and phytochemicals, such as organic acids, sugars, and phenolic compounds (Mikulic-Petkovsek et al., 2012a, 2012b). Goji berry (*Lycium barbarum* L.) is purported to benefit vision because of its high antioxidant (especially zeaxanthin) content. Some of these phytochemicals, which act as antioxidants, have recently been identified, and recent data show that they help to optimize human health by neutralizing free radicals in the body (Amagase et al., 2009; Donno et al., 2014).
The fruits are orange-red and sweet in taste. Traditionally, goji berries are collected in late summer to autumn, dried in the shade until the skin shrinks, and then exposed to the sun until the outer skin becomes dry and hard but the pulp is still soft (Amagase and Farnsworth, 2011).

The drying process is intended to remove water from foodstuff in order to prevent microbial spoilage and chemical alterations thus prolonging shelf-life while realizing space and weight saving (Cuccurullo et al., 2012; Cinquanta et al., 2010). The sun drying method is cheap, but there is a risk of damage due to dust and insect infection. An alternative is hot air drying. In general, the dehydration causes damages in texture, colour, taste and nutritional value of food due to the high temperatures and long drying times required in the process (Adiletta et al., 2014; Altimari et al., 2011; Brasiello et al. 2011, 2013; Russo et al., 2012).
Drying of goji berries is difficult because they contain a wax outer peel layer which acts as a barrier to moisture movement across the membrane and the health properties may be reduced by long exposure to high temperatures.
In previous studies, an alternative physical pretreatment, consisting of abrasion of the peel of grape (Di Matteo et al. 2000) and prune (Cinquanta et al. 2002), was proposed to reduce drying time and preserve the quality of final products.
The purpose of the present work is to study the effect of the abrasive pretreatment on goji berry (Lycium barbarum L.) after the hot air drying process at 60 °C. Drying kinetics, colour, antioxidant activity and sugar content were evaluated.

2. Materials and Methods

2.1 Sample preparation

Fresh goji berries (*Lycium Barbarum*) coming from Favella Spa farm (Sibari, Italy) with initial moisture content of 5.14 ± 0.96 g/g dry basis were used in the experiments. Before drying, some samples (fresh after pretreatment) were submitted to a physical abrasive pretreatment. The abrasion of the goji peel was carried out in a pilot system with motorized rotating drum (Di Matteo et al. 2000; Cinquanta et al. 2002). The drum was made of plexiglass, lined inside with sandpaper. The rotation speed of drum was 9 rpm, the pretreatment time was 15 min. A patent is applying for this new system.

2.2 Drying experiments

The drying experiments on goji berry were conducted, on 20 berries in each test, in a convective dryer (B80 FCV/E6L3, Termaks, Norway) at 60 °C with an air velocity at 2.1 m/s until a constant weight was reached. Two kinds of dried samples were compared in this study: dried untreated berries (UTR) and dried abraded berries (TR- Abr). The drying time was 21 h for UTR and 15 h for TR-Abr samples.
A load cell was used to continuously weigh the sample during drying. Moisture ratio (M_t/M_0) was calculated as the ratio between the moisture content at time t (M_t) and the initial moisture content (M_0) on dry basis (Adiletta et al., 2014). Drying experiments were carried out in triplicate.

2.3 Colour measurements

Colour measurements were carried out on ten (fresh or dried) berries. Colour was obtained through a colorimeter (Chroma Meter II Reflectance CR-300 triple flash mode aperture 10 mm Minolta, Japan). In order to analyze the colour change of all samples (fresh and dried), CIELAB L*, a* and b* colour coordinates were recorded using CIE L*a*b* uniform colour space (CIE-Lab). The lightness value (L*) indicates the darkness/lightness of the sample, a* is a measure of the greenness/redness of the sample and b* is the extent of blueness/yellowness. Chroma (C*) and Hue angle (H°) were calculated as follows:

$$C^* = \sqrt{(a^*)^2 + (b^*)^2} \quad (1)$$

$$H° = tan^{-1}\, b^*/a^* \quad (2)$$

Chroma indicates the dullness/vividness of the product while the Hue angle is how an object’s colour is perceived by human eye: red, orange, green or blue.

2.4 Antioxidant activity measurement

The antioxidant activity was evaluated by the DPPH scavenging method (Song and Xu, 2013). In its radical form, DPPH absorbs at 517nm, but upon reduction by an antioxidant, its absorption decreases.
The absorbance of fresh and dried samples was measured against the blank at 517 nm by a spectrophotometer (Lambda Bio 40; Perkin Elmer, Waltham, MA, USA) at room temperature. 100µL of the extract in methanol was added in a cuvette containing 2.9 mL of methanol solution of DPPH (0.1mM). The solution in the cuvette was shaken well and incubated in the dark for 60 min at room temperature.

By applying the same procedure to a solution without the test material a blank experiment was carried out; the absorbance was recorded as A_{blank}. The antioxidant activity was expressed as the percentage inhibition of DPPH (Albanese et al., 2013, 2014) and calculated according to the following equation:

inhibition of DPPH (%)= $100 * (\frac{A_{blank}-A_{sample}}{A_{blank}})$
(3)

The analysis of percentage inhibition of DPPH was replicated three times on three samples. The radical scavenging activity of DPPH was reported as % inhibition of DPPH /mg db (dry basis).

2.5 Sugar analysis
The fructose, glucose and trehalose concentrations were determined by HPLC method according to Di Matteo et al. (2003). The analysis were repeated three times on three samples and the averages are reported.

2.6 Statistical analysis
The means and standard deviations of experimental results were calculated from three replicates. One-way ANOVA (analysis of variance) at the level of significance $p < 0.05$ using Tukey's test was performed.

3. Results and Discussion

3.1 Drying kinetics
To compare the effect of pretreatment on the drying kinetics of goji berries, the curves of M_t/M_0 versus drying time are shown in Figure 1. It can be seen that M_t/M_0 of goji samples decreased with the increase of drying time and the abrasive pretreatment shortened the drying time significantly compared to the untreated samples. In particular, the TR-Abr samples showed faster moisture loss with respect to UTR ones: the drying time decreases from 21 h for UTR samples to 15 h for TR-Abr samples to reach the final M_t/M_0 value of 0.012.

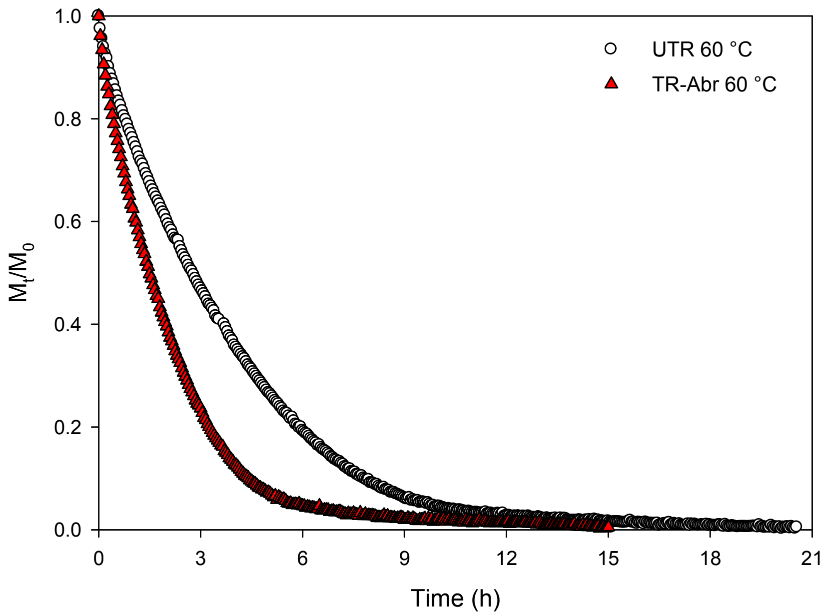

Figure 1: Moisture ratio of untreated (UTR) and pretreated (TR-Abr) samples during drying at 60 °C

3.2 Colour evaluation
The quality of fresh, before and after pretreatment, and dried samples was evaluated through measurements of colour. The results are presented in Table 1.
The pretreatment did not determine a change in the colour of fresh samples. As a result of drying, the variable L*, a* and b* decreased in both samples, even if a lower decrease in Hue angle and of Chroma was observed in TR-Abr samples than for UTR ones. These results show the effectiveness of abrasive pretreatment in better colour preservation of dried goji berries. The pretreatment seems to reduce the browning reactions by improving the water transport,.

Table 1. Colour parameters for both pretreated and untreated fresh and dried samples. Results are expressed as means ± standard deviation. Values in the columns followed by different letters are significantly different at p <0.05 according to Tukey's test.

Sample	L*	a*	b*	Hue angle	Chroma
Fresh	51.38 ±3.48[a]	30.95 ±2.25[a]	42.42±4.46[a]	53.82±1.98[a]	52.53±4.66[a]
Fresh after pretreatment	51.93 ±0.39[a]	31.28 ±2.76[a]	38.90.±5.66[a]	51.87±1.65[a]	49.53±4.13[a]
UTR dried	39.88 ±2.29[c]	12.47 ±2.31[c]	5.77 ±1.31[c]	24.73±2.07[c]	13.74±2.61[c]
TR-Abr dried	44.17±1.85[b]	27.81±1.32[b]	23.80 ±1.33[b]	40.58±1.55[b]	36.61±1.59[b]

3.3 Antioxidant activity evaluation

The antioxidant activity of dried goji berries was found significantly higher (20 % inhibition of DPPH/mg db) than other fruits, such as apricot (10 % inhibition of DPPH/mg db) and Red Globe grape (1 % inhibition of DPPH/mg db) as reported by Albanese et al. (2013) and Adiletta et al. (2015), respectively.

In details, the antioxidant capacity of TR-Abr dried samples was significantly stronger (21.30 %/mg db) than UTR dried ones (19.38 %/mg db).

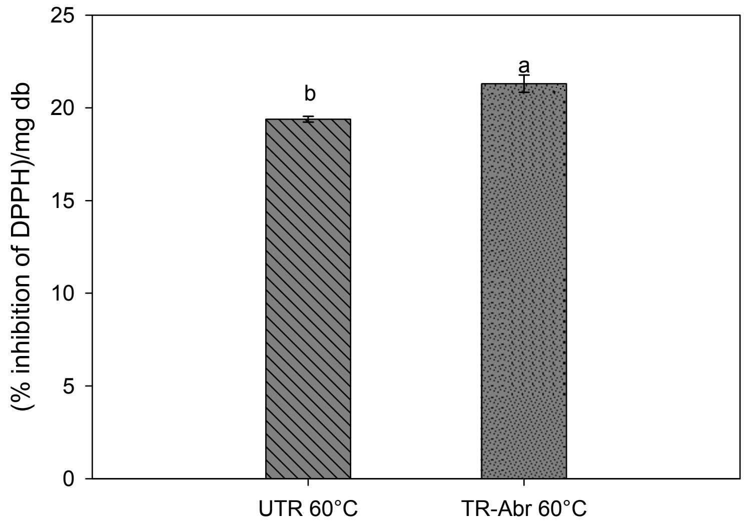

Figure 2: Antioxidant activity of untreated (UTR) and pretreated (TR-Abr) dried (at 60 °C) samples. Results are expressed as means ± standard deviation. Values followed by different letters are significantly different at p < 0.05 according to Tukey's test .

3.4 Sugar evaluation

Goji berries are a rich source of carbohydrates. In this study, glucose, fructose and trehalose were detected. As reported by other authors for grapes (Carranza-Concha et al, 2012), a reduction of sugar content was observed during drying, probably caused by non-enzymatic browning reactions (Figure 3). In details, a reduction of fructose content of about 23% was measured for both UTR and TR-Abr samples, while a lower decrease in glucose content (11-15%, respectively for UTR and TR-Abr dried berries) was observed. No significant difference ($p<0.05$) in fructose and glucose contents was found between dried samples. On the contrary, trehalose contents significantly different ($p<0.05$) were observed in fresh, UTR and TR-Abr dried samples.

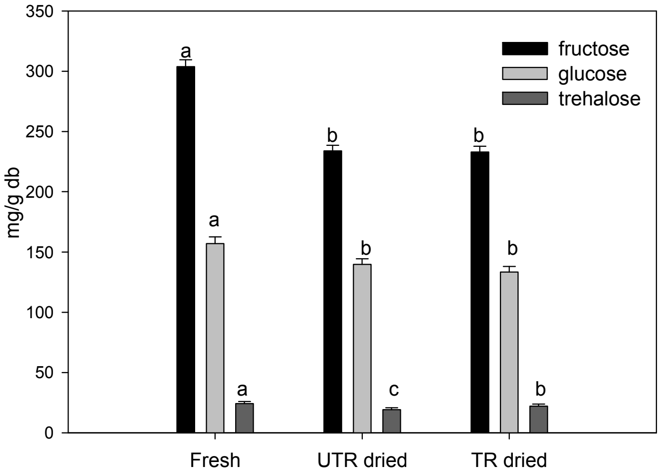

Figure 3: Sugar content (mg/g db) for fresh and dried samples. Results are expressed as means ± standard deviation. Values followed by different letters are significantly different at $p < 0.05$ according to Tukey's test.

4. Conclusions

In this study the effect of abrasive pretreatment on drying kinetics of goji berry was studied during hot air drying process at 60°C. Moreover, the quality of goji berry before and after drying was analysed. Pretreated berries showed reduced drying time, lower colour changes and similar sugar content than untreated samples. The faster release of moisture may be attributed to the lower resistance offered for diffusion of moisture by the skin, since wax present on the peel surface was removed by the physical pretreatment. Moreover, the antioxidant capacity of TR-Abr dried samples was found relatively stronger than UTR dried. These dried samples could be used as a dietary source of natural antioxidants and be worthy of development and utilization. In future work, the antioxidants present in goji berry fruit will be identified and characterized.

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