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Determination of the Optimum Drying Method in Terms of Color Value of Cress (*Lepidium sativum* L.) Leaves Dried by Microwave Method with Pre-Treatment and without Pre-Treatment

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ABSTRACT: Cress is belong to Cruciferae family and its origin is Asia. It is consumed both fresh and dried. In addition, there are many health benefits such as prevention of fat accumulation in body, diuretic, and appetitive. The objective of this study is to determine suitable drying conditions for preserving the best colour criteria that is the last quality value. In this study, the average of 5 color values was calculated by using the primary color values repeatedly measured in 9 different drying conditions (control, Fresh, 180 W, 360 W, 540 W, 720 W, and pre-treatment -without pre-treatment). The optimum drying condition was determined according to the fresh product. Drying process were carried out at 720, 540 360, 180 W power values with or without pre-treatment. Chroma (C), redness index (b / a), hue angle (h °), total color change (ΔE) and browning index values were calculated by measuring the primary color values of L, a and b after fresh and after drying. As a result of the study, the calculated values for the fresh product are 11.90, -1.43, -54.99, -, 13.07, respectively. 360 W power without pre-treatment was determined the most suitable for the color values.

Keywords – *Microwave drying, Pretreatment, Color values, Cress*

1. Introduction

Since the days of humanity, people have always used green leafy plants to meet their nutritional needs (Kendir and Guvenc, 2010). In addition to the nutritive properties of green leafy plants, they have healing effects in the treatment of some diseases. Using of green leaf plants have begun to increase in the field of alternative medicine since the last 20-30 years due to their active ingredients. Fresh green leafy plants are also rich in antioxidants and active substances such as ascorbic acid as well as strengthening the body 's immune system (Ahmed and Beigh, 2009; Kamel, 2013). It is known that there is a significant increase in the amount of cultivation of cress due to the nutritional value. The cress in terms of human health accelerates the fat burning, facilitates digestion, removes urine and it has a healing effect on the treatment of liver and biliary diseases (Aydın, 2011, Kabak et al., 2016).

It is necessary to preserve cress for a long time without spoiling to be able to consume outside of the seasons as well as fresh consumption in the season of cress. It is commonly stored in cold or by drying. However, the cold store method life has higher costs and lower shelf life than the drying preservation method. Therefore, cress that has approximately 90-95% the moisture content, must be dried in controlled conditions in order to be able to stay on the shelves for a long time without deterioration. Drying is one of the oldest methods of preserving agricultural products for a long period of time. The large amount of moisture product moves away while the product water activity value is reduced to prevent the growth of microorganism activities that extends product shelf life (Pisalkar et al., 2011).

In general, natural drying and forced hot air drying methods are preferred for drying products. However, in these drying methods, the process takes a long time, therefore, the product is exposed to heat for a long time. In this way both the energy consumption and the quality of the dried product are reduced. Thus, drying methods which causes the least amount of loss in terms of energy consumption, work time and quality values, should be preferred. Microwave drying is a popular method in drying processes in terms of achieving more protection in a shorter period of time and lower quality values of energy products than in other drying methods (Schiffmann, 2001; Sumnu, 2001; Diaz et al., 2003; Mao, 2008; Zhou et al., 2011).

In the literature, there are many studies on cress in many different topics and fields. However, any study is not found on determining the most suitable drying condition in terms of color value, which is an important criterion in terms of quality and commercial value of the dried product. The aim of this work is determination drying conditions for preserving the best colour criteria that is the last quality value.

2. Material and Methods

2.1. Drying material

The fresh cress used in the study was brought to the biosystem engineering drying laboratory after it was purchased from a local market in Tokat. Until the end of the drying process, products were stored at a temperature of +4 ± 0.5 ºC.

2.2. Moisture content

An average of 20 ± 0.5 g samples were used to determine the initial moisture level of cress before the drying process started. The moisture content of the product was dried by oven adjusted the temperature to 70 ºC until the change on the product weight becomes value of 0.01 (Yagcioglu, 1999). The moisture content of the cress known initial and final weights is calculated using the equations given in 2.1. and 2.2.

$$N_y = \frac{W_i - W_s}{W_i} \times 100 \tag{2.1}$$

$$N_k = \frac{W_i - W_s}{W_s} \times 100 \tag{2.2}$$

N_y: Wet basis moisture (%), N_k: Dry basis moisture (%), W_i: Initial weight of the product (g), W_s: Last weight of the product (g)

2.3. Drying methods

The stalks for cress were cut after washing and the bad part removed before the drying process started. The drying process is done by soaking and not soaking in hot water before drying at 180, 360, 540 and 720 W in power and time adjustable microwave dryer. Drying operations were carried out in 3 replicates and used average of 20 ± 0.5 g samples in each replicate. During the drying process the product was dried up to 10-13 % of the wet base. The microwave dryer used in the study is Vestel brand and MD-GD23 model with maximum power capacity 900 W.

2.4. Color measurements

Minolta brand CR300 color meter is used for color measurements of fresh and dried cress. The L, a, b values of the Hunter Lab Chroma meter color values were measured with this colorimeter.

These values are; "L" is a value between 0 and 100 when expressing the brightness value of the material. "a" indicates red-green, "b" indicates yellow-blue colors, and (+, -) signs respectively. (McGuire, 1992). While L, a and b values did not make any sense singly, they were used for calculating chroma value, redness index, hue angle, total color difference, and browning index values.

Chroma value: The expressed the darkness of the color product and has low values in pale colors and high values in vivid colors. Si et al. (2016) stated that the chroma value is calculated using the equation 2.3.

$$C = (a^2 + b^2)^{1/2} \qquad (2.3)$$

Redness index: It is determined by proportioning of the measured value of "a" to the value of "b". It expresses the value of redness of the product caused by drying conditions (Babalik and Pazir, 1997).

Hue value: The hue color angle value refers to what is the color corresponding to each angle in a color gradient of 360 °.

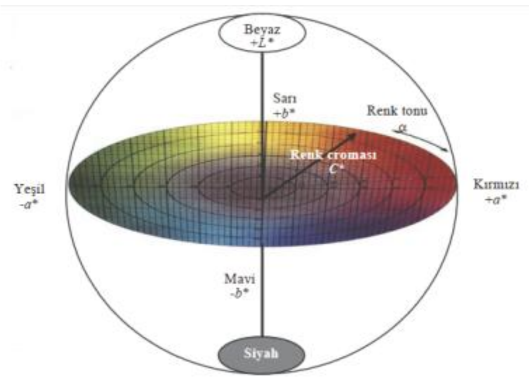

Figure 1. *The color gradient for hue angle (Cakir, 2015)*

It expresses that the product color is red in 0 °, yellow in 90 °, green in 180 °, blue in 270 °. Also, it is stated that intermediate colors formed in the between these angle values. (Figure 1). Polatci and Tarhan (2009) stated that the hue color angle value is calculated by using the equation 2.4.

$$h^{\circ} = \tan^{-1}\left(\frac{b}{a}\right) \quad (2.4)$$

Total color difference value: It is used to express the change between the measured color values of the fresh product and the color values after drying. The total color difference value was calculated using the equation 2.5. (Cakır, 2015).

$$\Delta E = \sqrt{(L_t - L_k)^2 + (a_t - a_k)^2 + (b_t - b_k)^2} \quad (2.5)$$

While L_t, a_t and b_t values express respectively brightness, fruity-green and yellow-blue color values of fresh product, L_k, a_k and b_k values express same values for the dry product.

Brownness index: The "BI" and "x" values symbolizes the browning index value of the product, represent the post-drying value of the product. Plou et al. (1999) stated that the "x" coefficient used to calculate this value with the browning index value is calculated using equations 2.6. and 2.7.

$$BI = \frac{[100\,(x - 0{,}31)]}{0{,}17} \quad (2.6)$$

$$x = \frac{a + (1{,}75\,xL)}{[(5{,}645\,xL) + (a - (3{,}012\,xb))]} \quad (2.7)$$

2.5. Determination of some chemical properties

The water soluble dry matter quantities, acidity values (pH) and titratable acidity values (T.A.) of the samples dried in fresh curing and drying conditions were determined in the study. The values closest to the specified properties of cress fresh have been determined as the most suitable drying methods in terms of applied drying operations.

3. Results and Discussion

3.1. Determination moisture content

The average moisture content of cress was determined as 92.02 % according to wet basis and 11.05 % dry basis. The drying properties of aromatic plants such as sage, rosemary, basil, thyme, mint, parsley and dill were studied and They detected that the initial moisture content of the average changed between 70-83 % and the final moisture content of the average changed between 6-12% in the literature (Gulcimen, 2008; Ayaz et al., 2016).

3.2. Color values

The measured L, a and b color values of cress fresh and dried are given in Fig.3.1.

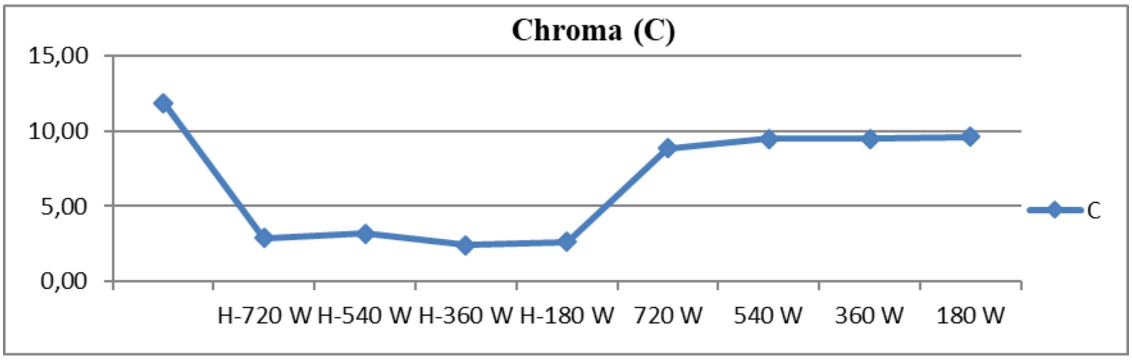

Figure 2. *Average chroma values of the product (C)*

In the Figure 2., the biggest chroma value of the cress was determined as fresh, while the smallest chromium value was determined in the samples dried at 360 W power with preliminary application. It has been determined that the chroma values of the products dried by pre-treatment and the chroma values of the products dried without pre-treatment are very close to each other. Alibas(2012) has dried up different power values at the leaves of the grapevine and he detected that the chroma value according to fresh have been preserved at least in high power applications.
The total color change values were determined under the drying conditions of the cress (Figure 3.).

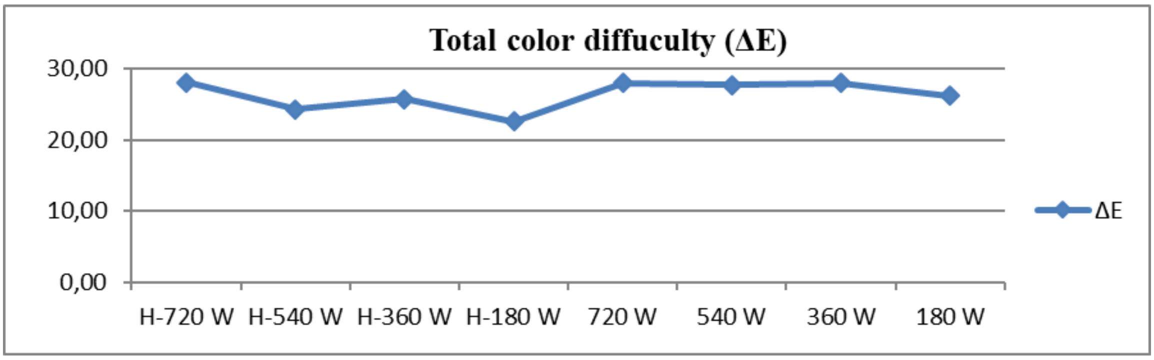

Figure 3. *Average change on colour of the product (ΔE)*

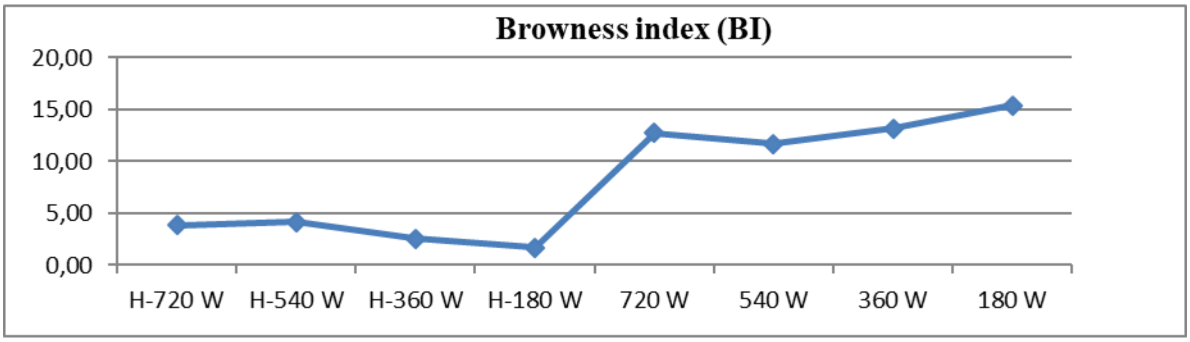

Figure 4. *Average brownness index of the product (BI)*

The maximum change in total color difference according to freshness in Fig 3.2. was determined in the products dried at 720 W power value by preliminary application and the minimum change was determined in products dried at 180 W power value by preliminary application. The browning index values under the drying conditions of the cress were determined (Figure 4.). According to Demir (2010), there has been a reduction in the value of the total color change in the carrot slices dried by the application of boiling water according to without pre-treatment.

In Figure 4., the maximum change in the value of browning according to freshness was determined in the samples dried at 180 W power without pre-treatment, while the minimum change was determined in products dried at 180 W power with pre-treatment. Polatcı and Tarhan (2009) dried basil plant in 280 W and 595 W power micro-wave for research of browning index values and they determined that there were less browning in the high power value.

The results of the multiple comparative Duncan test, which is determined by chroma, redness index, hue angle, total color change and browning index, calculated by the measured L, a, b values of the fresh and dried cress are given (Table 1.).

Table 1. *The average values of measured color values and calculated values*

Drying conditions	**L**	**a**	**b**	**C**	**a/b**	**H° degree**	**ΔE**	**BI**
Fresh	41.73^{a}	-6.81^{c}	9.75^{a}	11.90^{a}	-1.43^{a}	-54.99^{abc}	21.19^{a}	13.07^{ab}
Without pre-treatment 180 W	$33,85^{b}$	-4.97^{b}	8.24^{b}	9.64^{b}	-1.67^{a}	-58.86^{c}	$26,21^{bc}$	15.37^{a}
With pre-treatment 180 W	35.67^{b}	-5.12^{b}	7.97^{b}	9.49^{b}	-1.55^{a}	-56.90^{bc}	27.94^{b}	13.16^{ab}
Without pre-treatment 360 W	35.40^{b}	-5.48^{b}	7.70^{b}	9.49^{b}	-1.49^{a}	-55.23^{abc}	27.71^{b}	11.67^{b}
With pre-treatment 360 W	35.25^{b}	-4.64^{b}	7.50^{b}	8.86^{b}	-1.65^{a}	-58.04^{c}	27.94^{b}	12.77^{ab}
Without pre-treatment 540 W	24.96^{d}	-1.56^{a}	1.54^{c}	2.61^{c}	-1.15^{a}	-47.67^{a}	22.62^{d}	1.69^{c}
With pre-treatment 540 W	26.25^{d}	-1.57^{a}	1.81^{c}	2.42^{c}	-4.54^{a}	-54.00^{abc}	25.72^{bc}	2.55^{c}
Without pre-treatment 720 W	27.15^{d}	-1.95^{a}	2.52^{c}	3.20^{c}	-1.24^{a}	-49.77^{ab}	24.28^{cd}	4.18^{c}
With pre-treatment 720 W	30.59^{c}	-1.48^{a}	2.28^{c}	2.87^{c}	-1.88^{a}	-59.15^{c}	28.02^{b}	3.87^{c}

* *Average values compared according to $p<0.05$.*

It was determined that the effect of pre-treatment on the color values of the cress, was statistically significant *($p <0.05$)*. While there was no statistically effect drying process of pre-treatment at 180 W power on L, a, b, C, a/b values, there was statistically significant effect on of hue angle, total color difference and browning index values.

In all conditions dried according to Table 1., dry samples were statistically different than fresh samples in terms of brightness, redness, jaundice, chroma, total color change. Esturk ve Soysal (2010) has stated that when they dried fresh dill with microwave-hot air combination dryer, there was reduction in their brightness, redness and yellowness value according to fresh dill. Alibas (2012) dried to grape leaf with different power and they saw that when the increase in value of drying power, there was decline in L, a ve b value of the dried leaves. According to Polatcı ve Tarhan (2009), when they dried bacil with two different microwave dryer, there was reduction in their brightness, redness and yellowness value according to fresh bacil and the most reduction was high power micrewave dryer. Demir (2010) has stated that basic color values and chroma values were better preserved in the dried carrot slices by the application of boiling water according to without pre-treatment.

There was no statistically significant difference in redness index values between fresh cress and all drying conditions. According to the Hue ° values, there was no statistically significant difference between the pre-applied 360 W power value and the pre-applied 540 W power value. For the fresh cress, there is no statistically significant difference between the values of pre-applied 180 and 360 W in brown value.

When the secondary color value calculated according to Table 3.1 is compared according to the color, it is determined that in terms of color criterion is the most appropriate drying process is at 360 W power value without preliminary application.

3.3. Some chemical properties of dried and fresh cress

Some chemical properties of fresh and dried cress were determined in Table 2.

Table 2. *pH, brix and T.A values of cress fresh and dried cress*

Chemical properties	Drying conditions								
	Fresh	P-180 W	P-360 W	P-540 W	P-720 W	180 W	360 W	540 W	720 W
Brix	11,22	25,69	22,22	26,58	27,31	36,54	64,81	86,42	73,24
pH	6,25	6,75	6,68	6,73	6,96	6,36	6,54	6,63	6,55
T.A.	0,17	0,47	0,38	0,43	0,39	0,43	0,79	0,79	0,72

P: With pre-treatments, T.A: Titratable acid, brix: Amount of dry matter soluble in water

Total soluble solid values, pH and titratable acid (T.A.) values of fresh cress according to Table 2 were determined as 11.22, 6.25 and 0.17, respectively. There was a significant change on brix value of fresh cress according to dried cress. The closest brix value of the dried product to the fresh product was determined in pre-applied drying of 180 W power, while the farthest was determined in pre-treatment 540 W power drying. It has been reported that agricultural products dried by the application of boiling water may be reductions in the amount of total solible solid (Vaccarezza, 1975; Lewicki, 1998). Sat ve Öz (2015) determined that the pH of fresh and dried cress changed between 5.80-6.84 and also the T.A. of dried cress to fresh cress increased after drying. The closest pH value to fresh product is determined in pre-treatment drying of 180 W power, whereas the farthest was determined in pre-applied 720 W power. The nearest pre-applied titre ability acidy value of fresh cress, is determined in the drying process of 360 W power, the furthest titre ability acidy value was determined in the pre-applied drying process of 720 W power.

4. Conclusion

It was determined that the effect of pre-treatment on the color values in the study was statistically significant ($p < 0.05$). While there was no statistically effect drying process of pre-treatment at 180 W power on L, a, b, C, a/b values, there was statistically significant effect on of hue angle, total color difference and browning index values. Cress has a meaning compared to the secondary color values in commercial terms, while the closest color values according to fresh cress are determined at 360 W power without pre-treatment. For this reason, it has been determined that drying with 360 W power without pre-treatment is most suitable for the color criterion of dried cress in drying processes.

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