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Original Article

Effect of Ultrasonic, Microwave, Chemical, and Osmotic Pre-Treatments on Quality Indexes (Texture, Color, and Rehydration Ratio) of Dried Button Mushroom Slices in Hot Air Drying

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ABSTRACT

Objective: Button mushrooms (*Agaricus Bisporus*) are among the most widely produced and consumed mushrooms in the world. Generally speaking, mushrooms are of great nutritional value, which due to their high content of moisture and their corruptibility particular attention is required to be paid to their conservation and health. Drying is one of the most important ways to preserve the yields with high content of humidity. **Methods:** In this study, in order to increase the hold time and quality specifications, different pretreatments including osmotic ($NaCl_2$ with a 10% density ratio), chemical (metabisulfite potassium with concentration 0/5% density ratio), ultrasound (with a frequency of 28 ±0/5 (KHZ)), and microwave (with power 360 watt) were applied. These pretreatments were dried through the hot air method. Osmotic, chemical, and ultrasound pretreatments were used for 2 h, 30 minutes, and 30 minutes, respectively at ambient temperature, while the microwave was employed for 4 minutes. Then effect of various pretreatments on the dried button mushrooms' quality indexes such as texture, color, and rehydration ratio was investigated. **Results:** Based on the results, with regard to the tissue of samples under various pretreatments, a highly significant difference at 1% level can be observed for the hardness and adhesiveness indexes, while a significant difference exists for the chewiness index at 5%. After comparison, the maximum hardness was seen in the control sample, and hardness value of the samples under various pretreatments was lower than that of the control. Among the samples with ultrasonic, microwave and osmotic pretreatments, no significant difference was observed and the lowest hardness value belonged to the samples with chemical pretreatment. The samples under chemical pretreatment comprised the lowest chewiness value. Furthermore, no significant difference was observed in the other pretreatment and control samples. The least adhesiveness value belonged to the samples with microwave, osmotic, and ultrasound pretreatments. The sample with chemical pretreatment had the highest adhesiveness. The best color was related to the osmotic samples, and control samples showed a low quality. In general, the samples with pretreatments had better color than the control ones. The lowest rehydration ratio was obtained in the samples under chemical and control pretreatment, respectively. Therefore, application of various pretreatments significantly contributes to the improvement of quality specifications, where chemical pretreatment is of great importance.

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INTRODUCTION

Button mushrooms (*Agaricus Bisporus*) are the most widely consumed mushrooms (comprising about %40 of the total mushroom consumption) in the world (Giri and Prasad, 2007). According to Food and Agriculture Organization (FAO) in the year 2010, about 7/5 million tons of edible mushrooms were produced in the world, of which about 5 million tons were produced in the continent of Asia. China with a yearly production of about 4/9 million tons of mushrooms is the first rating in the world, and America, Italy, and the Netherlands follow, as shown in Figure 1. According to the statistics, Iran with a production of 27500 tons is the sixteenth largest mushroom producer in the world. Edible mushrooms are food sources of high-protein and fewer calories, and have the salts and minerals including iron, calcium, potassium, phosphorus, copper, and vitamins such as groups B, C and D. Mushrooms have 32/7% protein, 2/4 % fat and 47/7 % carbohydrates (Kotwaliwale et al. 2007). In addition to their properties, edible mushrooms are also effective in treating many diseases. Recent research implies the importance of mushroom compounds to prevent many cancerous diseases such as prostate cancer in men (Adams et al. 2008). Mushrooms are very sensitive to moisture and decay quickly because of their high moisture content (about 90% based on the wet). The color and texture of mushrooms transform after harvest due to the reduction in the moisture and shrinkage, (Kulshereshta et al. 2009) and browning reactions occur quickly.

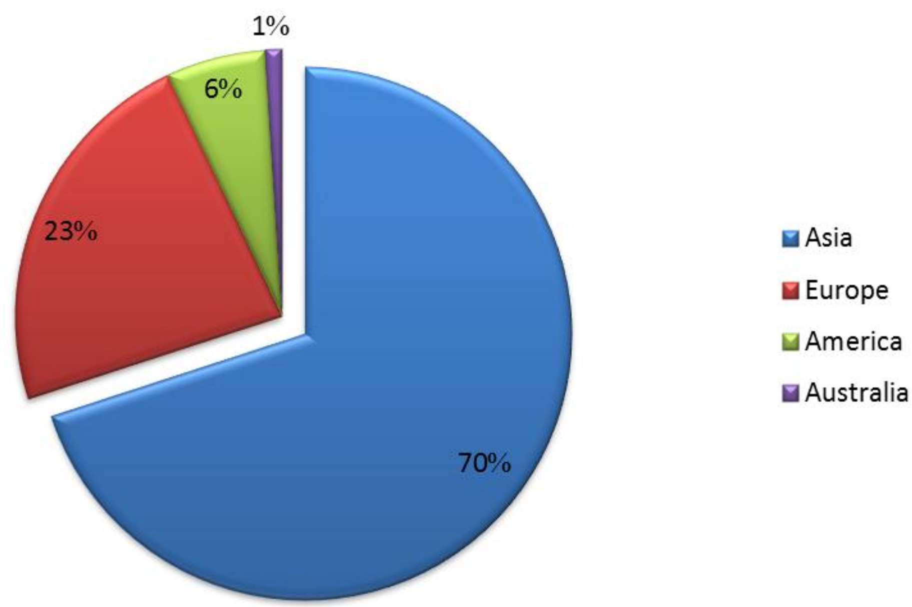

Figure1:
Mushroom-producing nations in the world in 2010

There are several ways to control browning (e.g., heat, sulfur dioxide and sulphite, sodium chloride, acids, less PH, Blanching and pasteurization). Addition of sulfur dioxide and sulfites to the bisulphate and metabisulphite is effective in the control of browning and inhibition of browning reactions during storage and shelf-life under adverse conditions and undesirable temperature (Mujumdar and Sablani, 2006). Mushrooms can be stored under initial conditions and postharvest up to 24 hours, and hence they quickly decay (Giri and Prasad, 2007). Therefore, they should be immediately consumed or processed. Drying is one of the most common and suitable methods for the maintenance of the product. Moreover, this method is cost-effective, compared to the other existing methods. Dried mushrooms in chambers impervious to air can be kept up to one year (Walde et al. 2006). However, mushrooms are sensitive to heat, and selection of appropriate drying method is a major factor in the success of the process (Giri and Prasad, 2006). Hot air drying is the most common method for drying fruits and vegetables. In this method re-rehydration of product, due to the hardening of the shell is difficult (Ebrahim rezagah et al. 2009). To solve this problem, combinational methods such as drying air hot-vacuum (Zecchie et al. 2011), osmotic- air hot (Shukla and singh, 2007), and air hot- microwave (Shamaee and Emamjomeh, 2010) have been applied. In addition to controlling the drying conditions, there are other factors to produce a desirable product (Ebadizadeh et al. 2003). Application of physical and chemical pre-treatments can be considered before the drying process. They help to keep the texture characteristics and color stability and increase maintenance taste (Walde et al. 2006). Results of Shamaee and Emamjomeh (2010) showed that application of chemical pretreatment of potassium Metabisulfite improved water absorption rate. Also, results of Ebadizadeh et al. confirm that different pretreatments have different effects on the color and reduction of pollution. In another study, dried mushroom slices helped to pretreatment chemical sulfitasion and blanching in hot-air drying. Results show that the drying temperatures have a negative effect on the color of dried mushrooms, while sulfitasion helps in white of color of the dried samples. Blanching also leads to the browning of the color in dried mushrooms slices (Kotwaliwale et al. 2007). Results of Zecchi and et al. (2011) showed that through temperatures of 350, 450, and 550℃, in the temperature of 550℃, in addition to maintaining the quality of dried mushrooms, drying time reduced. Therefore, the 550 ℃ was chosen as the best temperature. Kulshereshta et al. (2009) also showed that through temperatures of 500, 600, 700℃, temperature of 500 ℃ was introduced as the optimum temperature for drying. This temperature helps in the maintenance of dried samples' color, reduced shrinkage and a good rehydration ratio. Effects of other pre-treatments including osmotic (Ebrahim rezagah et al. 2009), (Shukla and singh, 2007), Microwave (Shamaee and Emamjomeh, 2010), ultrasound (Fabiano et al. 2009), (Jambrak et al. 2007) have also been reported. Pre-treatments of chemical including the use of metabisulphite, such as metabisulphite sodium (Ebadizadeh et al. 2003) and metabisulphite potassium (Kotwaliwale et al. 2007), acids such as acetic acid, ethylene-diamine-tetra acetic acid (EDTA) (Eissa et al. 2009) and the combination of pretreatments (Fabiano et al. 2009) have been reported.

Therefore, this research was performed to investigate the effect of different physical and chemical pre-treatments (osmotic, chemical, microwave and ultrasound) on the quality characteristics of dried button mushroom slices in hot air drying.

2. MATERIALS AND MTHODS

Button mushrooms (*Agaricus Bisporus*), produced by Dezful Mushroom Company were bought from a market in Iran. These mushrooms were stored in a refrigerator at 60℃ . Before starting the test, for uniformity with ambient temperature (27℃), the mushrooms were exposed to this temperature. Samples were sorted by their size, and medium-sized samples were chosen. Samples were cut to a thickness of 3 mm. Moisture content of the samples was measured by heating in an oven with a temperature of 130 ± 2^0c to reach a constant weight (AOAC, 1990). In order to remove the enzymatic browning reactions, blanching operations was performed by Benmary set (Model DINEN 60529-1P20) for 2 minutes on all samples before applying the original pretreatment. Then the samples were cooled quickly with cold distilled water, and their surfaces were dried by filter paper. After that, pretreatment was performed on the enzymatic samples. To apply microwave pretreatment, a domestic microwave (brand LG, model LF-5905SCR made in Korea with frequency 2450 MHZ and maximum thermal power of 900 watts), which could be adjusted in 90, 180, 360, 600 and 900 watts, was used. In order to choose the best power level and pretreatment time, preliminary tests were conducted. According to preliminary tests maximum level of power, which the most out of water and also the least negative effect on the samples was chosen. After preliminary testing, the power of 360 watts for 4 minutes was chosen. Consequently, enzymatic samples were stacked on plastic baskets, special of microwave, and were placed inside it. In order to uniform effect of waves on whole samples, two baskets were used. They were placed inside the microwave to form symmetry, and then they were displaced and rotated for 2 minutes. In order to apply osmotic pretreatment, sodium chloride ($NaCl_2$) with concentration 10% density ratio, a speed of 400 (rpm) for 2 hours at room temperature was chosen. After the preliminary tests, chemical pretreatment (metabisulphite) was applied considering its positive impact on the structure and desirable quality with concentration0/5% density ratio for 30 minutes at room temperature (Shamaee and Emamjomeh, 2010). To apply the ultrasound pretreatment, ultrasonic bath (model Pars 7500 S. Manufacture pars-Iran) with Frequency 28$\pm$0/5 (KHZ) at temperature 30^0 C (Ebadizadeh et. al. 2003) for 30 minutes on Blanching samples was used. Then pretreatment samples were dried in the hot air oven (model lit150 OMT-, manufactured by SANYO), with a temperature of 55^0c. Samples were placed out of the oven for 1 hour, and they were weighed with digital scale (accuracy of 0/01 g) and drying operations was continued until moisture content of 6 % - 8 % dry basis. In order to evaluate texture, was used of Texture Analyzer (model QTS). Therefore, dried samples were immersed in 400c water for 30 minutes. Then samples were out of water and theirs surface water was absorbed by the filter paper. Texture analysis based on TPA tests was performed. During this test, cylindrical probe with a diameter of 6 mm and the diffusion constant speed of 10 mm was used.

To obtain a digital image, a scanner (model Canon-mp210 manufacture of Korea) was used. After scanning the samples, color analysis was performed using Adobe Photoshop 8. To describe the color changes, during drying, from ΔE index (different color dried samples of fresh mushrooms) was used. The index is defined as follows:

$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$$

Where $\Delta L = L - L_o$, $\Delta a = a - a_o$ and $\Delta b = b - b_o$ are indexes of different lights, red and yellow. L, a and b is as for dried sample, and L_o , a_o , b_o as for fresh sample.

From each iteration of test, 3 sample was randomly selected and from each sample five points, including the top, bottom, left, right and center were randomly selected (Artnaseaw et al. 2010).
Finally, the average values for each iteration are composed of 15 points and the color indexes and ΔE were obtained. To measure the rehydration ratio, 1 g of dry sample was immersed in 100 ml of distilled water (Ebrahim rezagah et al. 2009) and the temperature was 40^0c for 30 minutes.
Then samples were exited in the water and after absorption of moisture by filter paper, they were weighed with digital scale (precision 0/01 g). The moisture content of samples that water absorbed according to AOAC (1980) was examined. The moisture content after absorption of water can be formulated as the normal moisture content (NMC) as follows.

$$NMC = \frac{X_t}{X_o}$$

Where X_t and X_o represent the normal moisture content at time t and the initial time, respectively.

The experiments were conducted in a completely randomized design, and the results were analyzed by software MSTATC and SPSS18. Means were compared using Duncan's test. Excel software was used for drawing diagrams.

3. RESULTS AND DISCUSSION

3.1. Indexes of tissue

Results of analysis of variance from tissue indexes (hardness, adhesiveness, chewiness, and cohesiveness) are shown in Table 1. Concerning the tissue of samples under various pretreatments, results of hardness and adhesiveness indexes demonstrate a highly significant difference at 1%, whereas the chewiness index showed a significant difference at 5%. After comparison, the maximum hardness was observed in control samples and hardness value at samples of under various pretreatments was lower than that of the control. Among the samples with ultrasonic, microwave and osmotic pretreatments no significant difference was observed and the least hardness value was related to the samples with chemical pretreatment. The Samples under chemical pretreatment allocated the least chewiness value to themselves. No significant difference was observed among other pretreatment samples and control samples. The least adhesiveness value was associated with the samples with microwave, osmotic and ultrasound pretreatments. The sample with chemical pretreatment had the most adhesiveness. Also the results of cohesiveness index showed that the most cohesiveness belonged to control and chemical pretreatment, respectively. The least cohesiveness was observed in samples with osmotic pretreatment (Figure 2).

Table1:

Analysis of variance of affect pretreatments on various indexes of texture

	df	MS	SS	F
Sov		**hardness**		
pretreatment	4	50.93	732.21	5.272**
error	10	24.15	2.41	
total	14	75.08		
		chewiness		
pretreatment	4	2.318	0.579	3.122*
error	10	1.856	0.186	
total	14	4.174		
		adhesiveness		
pretreatment	F	0.079	0.02	495.83**
error	10	0.004	0.0004	
total	14	0.08		
		cohesiveness		
pretreatment	4	0.275	0.069	14.063**
error	10	0.049	0.005	
total	14	0.324		

* : significant difference in level 0/05% , ** : significant difference in level 0/01%

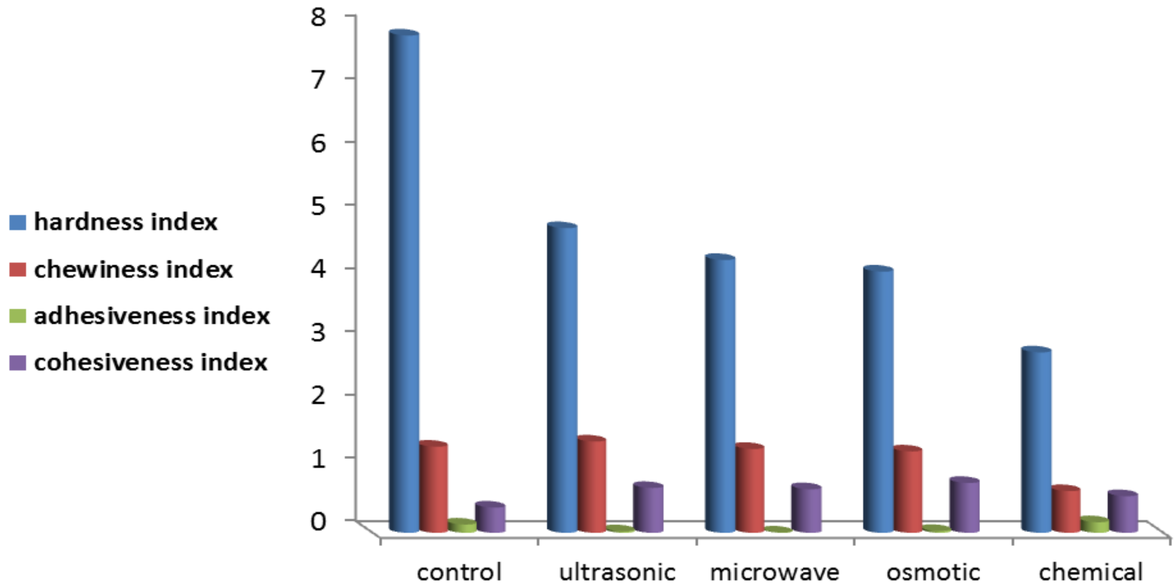

Figure2:
Affect pretreatment on various indexes of tissue

3.2. Indicator color changes

The results of analysis of variance showed that color changes index of samples had a very significant difference (at 1%). After finding the means, the best and the least color were shown to be in samples of osmotic and control, respectively. In general, the samples with pretreatments had better color than the control (Figure 3).

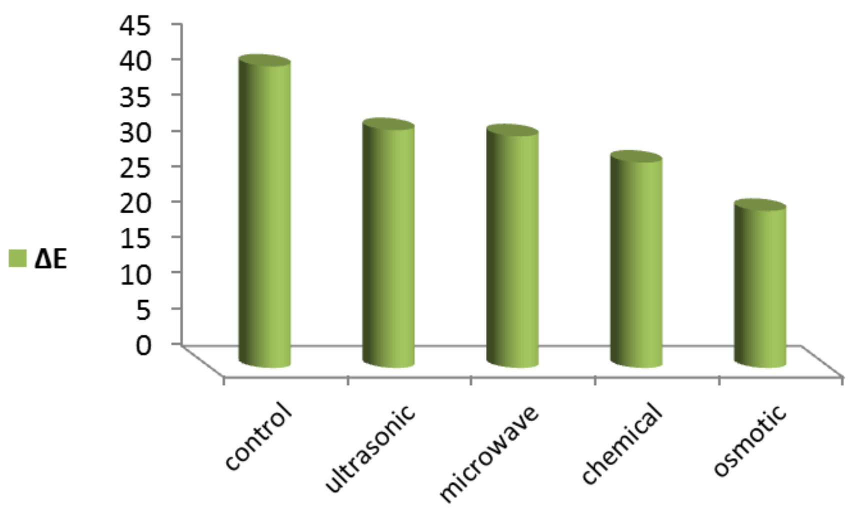

Figure 3:
Affect pretreatment on color changes

3.3. Rehydration ratio index

The results of variance analysis showed that rehydration ratio index of samples had a very significant difference (at 1%). The most rehydration ratio obtained respectively in the samples under chemical pretreatment and control. It can be partly accounted for by the fact that the low rehydration ratio was the penetration of the solids within the tissue – as reported by shukla and Singh (2007).

No significant differences exist between the samples of microwave and ultrasound pretreatments (Figure 4). With the observation of the cohesiveness values, it can also be concluded that the increase in the tissue cohesiveness may result in a decrease in the rehydration ratio.

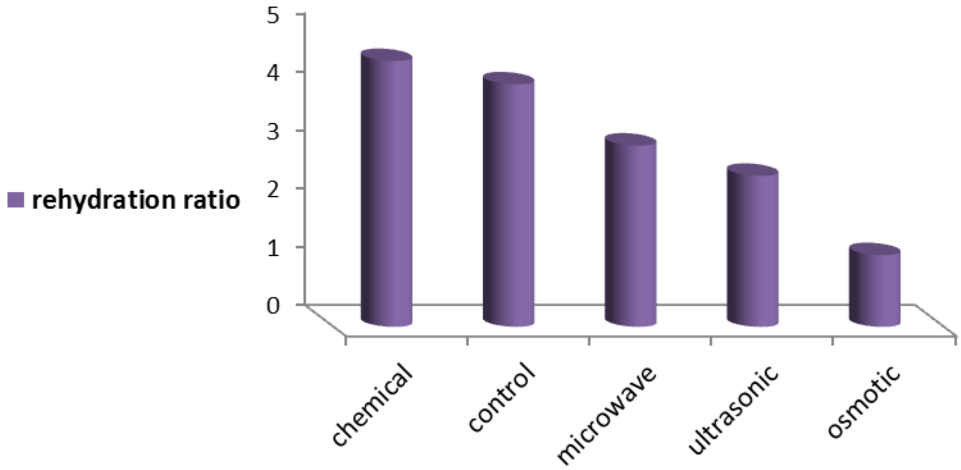

Figure 4:
Affect pretreatment on rehydration ratio

Conclusion

Effect of different treatments on the qualitative attributes of mushroom slices such as texture, color, and rehydration ratio under the hot air drying were evaluated. Chemical pretreatment increased structural properties and rehydration ratio rate. Besides, it demonstrated a good quality of dried samples and the least value of chewiness and hardness, compared to the other pre-treatments. Our obtained result is in agreement with the findings of Walde et al. (2006) and Kotwaliwale et al. (2007). Therefore, application of various pretreatments helps to keep the quality specifications, and chemical pretreatment has a considerable impact.

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