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RESEARCH ARTICLE

Preliminary post harvest treatments for improving shelf life of white button mushroom (Agaricus bisporus)

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Abstract

Agaricus bisporus (white button mushroom) is highly perishable and there is a need to devise economical and practical techniques which result in minimal colour and textural changes so as to extend the shelf life and allow easy transportation of harvested mushrooms to far off markets. In this study freshly harvested fruit bodies of A. bisporus strain U-3 were graded before subjecting them to different washing treatments [plain water, citric acid (0.5%), potassium metabisulphite (0.05%) or combinations of these washings with blanching (40 sec)] and observations were made on physical (color and texture) and biochemical (polyphenol oxidase enzyme) properties to elucidate the optimum preliminary treatment of these mushroom strains. There were significant differences in the overall color difference (ΔE) calculated on the basis of the L, a and b values and ΔE was least for the treatment of blanching + CA+ KMS. Texture analysis showed that hardness decreased in all treatments where blanching of the mushroom strains had been done. Among these treatments, maximum hardness (1361.02 gm) was recorded in treatment T7 (Blanching + CA + KMS). The minimum PPO activities (0.036 $U.min^{-1}$ gm^{-1}) were observed in treatments T7 (Blanching + CA + KMS).

INTRODUCTION

Button mushroom (Agaricus bisporus) accounts for about 35% of total world production of mushrooms. Consumption of mushrooms has increased substantially due to their delicacy, flavour and nutritional value. Mushrooms are an excellent source of several essential amino acids, vitamins (B_2, niacin and folates) and minerals (Shivhare et al 2004). Mushrooms have a shorter shelf life because of a high water content and the shelf life of fresh mushrooms is less than 2-3 days under usual shipping and marketing conditions. The problem of marketing and transportation of mushrooms to far off places are many and large quantities are lost for want of adequate and timely disposal. For this reason it is imperative to devise some economical and practical techniques to extend the shelf life of this perishable commodity so that it can be easily transported to far off markets.

Fresh mushrooms are highly perishable as browning reaction and weight losses continue to occur. Mushroom have a higher enzyme activity than most vegetables and blanching stops enzymatic action and prevents browning of mushrooms. The mushrooms browns very quickly and antioxidant solutions such as citric acid or lemon juice have been reported to prevent to undesirable browning reactions. Mushroom browning occurs as a result of two distinct mechanisms of phenol oxidation: (a) activation of tyrosinase, an enzyme belonging to the polyphenoloxidase (PPO) family; (b) and/or spontaneous oxidation (Nerya et al 2006). Enzymatic browning is a consequence of PPO catalyzed oxidation of phenolic substrates into quinones, which undergo further reactions to dark pigments called melanins. The major PPO enzyme responsible for browning in mushrooms appears to be

tyrosinase (Jiang et al 2011).

According to Sapers et al (2001), preliminary processing used is washing. It is one of the first measures applied in processing of mushrooms. Although it is desirable from the point of view of hygiene, the washing of pilei in water alone considerably decrease the quality of stored mushrooms. To improve and maintain whiteness many pretreatments have been tried. Washing with EDTA, H_2O_2, KMS, $CaCl_2$, sodium hypochlorite etc have been tried. Steeping preservation of mushrooms (Sandhu and Aggarwal 2001) is convenient as well as economical for extension of the shelf-life of mushrooms while blanching (Coskuner and Ozdemir 2000) in water can be applied to preserve the good color. However, in this case blanching must be preceded by washing the raw material in a solution of potassium metabisulphite. Okereke and Beelman (1990) showed that, compared with blanching in water and using brine made from table salt, blanching in a solution of citric acid, the use of brine made from table salt and sodium–calcium salt of versenic have a positive effect on color and texture of sterilized mushrooms along with an increase in the microbiological stability of products.

The effect of different chemicals like citric acid (0.5%),potassium metabisulphite(0.05%) or combination of these washings with blanching(40 sec) on strain U-3 have not been done till now. So the present study was therefore, planned with the objective of standardization of washing/blanching of the fresh mushrooms of strain U-3 with minimal loss of quality and nutritional attributes.

2. Materials and methods

2.1 Post harvest treatments

Cultivation: The cultivation trials were conducted indoor under natural climatic conditions of temperature (14-27^0 C) and relative humidity (70-90%) at the PAU Mushroom Research Complex using standard methodology (Khanna and Kapoor 2007). Wheat grain spawn was prepared using the standard methodology of Khanna and Kapoor (2007).

Washing: Mushroom fruit bodies were freshly harvested into 4 lots each weighing 1200g and washed with plain water, potassium metabisulphite (0.05%), citric acid (0.5%) and twice washing with potassium metabisulphite (0. 05%) for 5 minutes. After dipping treatment, excess of solution was drained off and the fruit bodies were allowed to air dry on muslin cloth.

Blanching: For studying the effect of blanching fruit bodies were harvested into 4 lots each weighing 1200 g. The fruit bodies were blanched prior to the washing treatments. The fruit bodies were blanched in boiling water for 40 sec, followed by washing with either plain cold water, CA(0.5%) KMS (0.05%), CA (0.5%) + KMS (0.05%). After dipping treatment, excess of solution was drained off and the fruit bodies were allowed to air dry on muslin cloth.

2.2 Color detection

The color of freshly harvested and the treated samples was measured by using Miniscan XE plus Hunter Lab Colorimeter. Measurements of color was taken at an observer angle of 10^0 C. Before measuring the color, the colorimeter was calibrated using white and black tiles provided with the equipment and standardized with white tile, the mushroom cap was placed in close contact with the colorimeter lens so that the light which falls on the samples should reflect back and no light is transmitted to the surroundings (Burton et al 1987, Gormley 1974).

It gives measurements of color in units of approximate visual uniformity throughout the color solid. L, a, b values for samples were obtained in triplicate. 'L' depicts lightness, 'a' depicted redness and 'b' depicted blueness. The readings were taken in triplicates. From these values of 'L', 'a' and 'b' coordinated directly. The ideal mushroom color values of L= 97, a = -2 and b=0.

Total color difference was obtained using the formula: $\Delta E = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}$

2.3 Texture analysis

The textural behavior of the whole mushroom was estimated in terms of the texture profile analysis (TPA) curve. The parameters of brittleness, hardness, cohesiveness, adhesiveness, Chewiness, springiness and gumminess were calculated from the plot of two cyclic compression text performed on mushrooms sample of about 5 mm thickness using an aluminium cylinder known as P/75 cylindrical probe having 75 mm diameter.

2.4 PPO activity

One ml of crude enzyme extract prepared from the different treated mushroom samples was added to 3ml substrate (0.075 M catechol solution) mixed thoroughly and cuvette was placed immediately in spectrophotometer at 495nm absorbance. The substrate solution was used as blank reference sample for zero setting of spectrophotometer. The change in absorbance was recorded for every 30 seconds upto 120 seconds.

Results and discussion

The observations recorded after preliminary treatment of the mushrooms by washing (plain, citric acid**,**

KMS or their combinations) and/or blanching indicated that color measurement of L* value decreased in all treatments compared to fresh mushrooms. Compared with other treatments, Blanching + CA + KMS showed the least reduction of L* value compared to fresh mushrooms. (L* value 69.84) The L* value is normally highest for fresh samples. Treatments T5 (Blanching + CA), T7 (Blanching + CA + KMS) and T8 (KMS + KMS) were at par with each other but were statistically significantly compared to all other treatments. There were significant differences in the overall color difference (ΔE) calculated on the basis of the L, a and b values of different treatments. ΔE was least for the treatment of blanching + CA+ KMS. The change in color was mainly due to enzymatic browning. The oxidation of phenols by PPO enzyme resulted in the browning complex (Yamaguchi et al 1970, Nichols 1985, Rai and Saxena 1988, Bartley et al 1991).

One of the main changes associated with mushroom deterioration are changes in texture (Ares et al 2006, Parentelli et al 2007). Kojo et al (2004a, b) established another method to analyse the texture properties based on the changes of tenderness, pliability, toughness and brittleness of post-harvested and cooked mushrooms. The texture of the fresh fruit bodies and treated mushrooms were analyzed by a texture analyzer. It was observed that hardness decreased in all the blanched treatments compared to washing treatments. Among blanched treatments, the fruit bodies of U-3 strain under treatments T7 (blanching + CA + KMS) retained maximum hardness followed by treatment T5 (blanching + CA) and T8 (KMS + KMS).

It was found that the treatment T7 (blanching + CA + KMS) was statistically significant in terms of retaining the overall texture of the fruiting bodies compared to all other treatments and showed maximum hardness of 1361.02 (Table 1). The findings are supported by the studies of Bernas et al (2007) and Master et al (2000) who also reported that blanching or 'blanching and freezing' brings about a decrease in the hardness and stiffness of mushrooms respectively. Czapski (1994) also showed a decrease in hardness in Agaricus bisporus mushrooms blanched in water for 6 min as measured in a CS-1 Kramer shear cell, the changes amounting to 20–40% compared to the raw material. He also noted that storing the mushrooms for 18 h at 2 °C followed by vacuum impregnation with water for 5 min before blanching brought about a small increase in hardness. Master et al (2000) found that blanching Agaricus bisporus in hot water for 1 or 10 min reduces stiffness in caps by 45 and 90%, respectively.

It has been documented that polyphenoloxidase (PPO) enzyme is responsible for browning of damaged fruit and vegetables by cataysing hydroxylation of monophenols to O-diphenols and dehydrogenation of O-diphenols to O-quinones in the presence of O_2 (Lagnika et al 2011).During the present studies, fruit bodies under blanching treatments T4 to T8 showed least PPO activity and were all at par with each other followed by treatment T3 (KMS). All other treatments were significantly different from these and from each other. Fruit bodies washed with only plain water retained the maximum enzyme activity. The major PPO enzyme responsible for browning in mushrooms appears to be tyrosinase (Jiang et al 2011). Mushrooms do contain sugars, amino acids and proteins and hence, non-enzymatic browning is inevitable when this high moisture content product is stored above 5°C (Swaminathan, 1988). Findings of the present study are consistent with the observations of Czapski and Szudyga (2000) who reported that washing of button mushrooms in water caused an increase in storage browning of mushrooms. Sulfur dioxide and its derivatives are the most powerful and extremely versatile PPO inhibitors, which inhibit enzymatic as well as nonenzymatic browning of vegetables, fruits, and mushrooms during their storage, freezing, and processing (Roberts and McWeeny 1972, Laurila et al 1998). It is for this reason that the mushrooms washed with KMS in different treatments during the present study also showed lower PPO activity. Further blanching treatments results in inactivation of the browning enzyme and is also effective in preventing browning of the mushrooms.

A pre-treatment combination of blanching (40 sec) + citric acid (0.5%) + KMS (0.05%) washing of the freshly harvested mushrooms of strain U-3 results in the production of best button mushrooms with good postharvest keeping quality.

Table 1: Effect of different postharvest treatments of Agaricus bisporus strain U-3 on whiteness (L-value), texture analysis and polyphenol oxidase activity

Treatments	Whiteness (L-value)	TPA (hardness in gm)	Polyphenol oxidase activity (U min^{-1} gm^{-1})
T1 - Water	59.41	1002.64	0.052
T2 – Citric acid (CA)	58.83	1075.34	0.048

T3 – KMS	61.63	1147.86	0.044
T4 – Blanching (B)	58.70	1099.09	0.038
T 5 - B + CA	68.20	1172.28	0.038
T6 – B + KMS	65.31	1261.94	0.039
T7 - B + CA + KMS	69.84	1361.02	0.036
T8 – B + KMS + KMS	69.27	1154.06	0.040
Control (Fresh mushrooms)	88.17	1425.63	0.098
CD (5%)	3.27	102.61	0.012

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