DETERIORATION AND SOME OF APPLIED PRESERVATION TECHNIQUES FOR COMMON MUSHROOMS (AGARICUS BISPORUS, FOLLOWED BY LENTINUS EODES, PLEUROTUS SPP.)

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INTRODUCTION

Mushrooms have been placed in a kingdom of Mycetaceae and is a "macrofungus with a distinctive fruiting body, which can be either epigeous or hypogeous and large enough to be seen with naked eye and to be picked by hand" (Cheung, 2008). The number of recognized mushroom species has been reported to be 14,000, which is about 10% of the total estimated mushroom species on the earth (Cheung, 2008; Koushki et al., 2011). Total commercial mushroom production worldwide has increased from about 350,000 tons in 1965 to about 3.4 million metric tons (Koopman and Laney, 2010). The most cultivated mushroom worldwide is Agaricus bisporus1, followed by Lentinus edodes2, Pleurotus spp3, Auricula auricula4, Flammulina velutipes5 and Volvariella volvacea6 (Aida et al., 2009).

Mushrooms have good quality proteins with lysine and tryptophan. The carbohydrates in the mushrooms are at a level of 4.5 to 6.0% but are in the form of glycogen, chitin and hemicellulose instead of starch. The fat contain is as low as 0.3% but is rich in linoleic acid, an essential fatty acid. Furthermore, Mushrooms are fairly good source of vitamin C and vitamin B complex, particularly thiamine, riboflavin, niacin, biotin and pantothenic acid. Folic acid and vitamin B12 which are absent in meat. Mushrooms are highly perishable and their shelf life depends on processing, package properties and environmental conditions during storage and distribution. The main processes which contribute to loss in mushroom quality after harvest are (i) discoloration, (ii) bronzing, (iii) loss of closeness, (iv) weight loss and (v) texture changes (Aguirre et al., 2009).

Mushroom Deterioration

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Mushrooms are highly perishable and their shelf-life is limited to a few days under normal refrigeration conditions, which is a constraint on the distribution and marketing of fresh product, making extension of mushroom’s shelf life a constant quest. Modified atmosphere packaging provides an affordable packaging system that partly avoids enzymatic browning, fermentation and other biochemical processes by maintaining a controlled gas atmosphere. However, modified atmosphere packaging conditions should be carefully designed. Inappropriate modified atmosphere conditions may be ineffective or even shorten the shelf life of the product due to damage of tissues. Preservation techniques and specially use of MAP, specifically for Agaricus, Lentinus edodes and Pleurotus, is reviewed.

Keywords: Deterioration, preservation, mushroom, Agaricus bisporus

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ABSTRACT

Mushrooms are considered as a nutritional and health beneficial product. Three most cultivated mushrooms worldwide are Agaricus bisporus, Lentinus edodes and Pleurotus spp. Mushrooms are highly perishable. They tend to lose quality after harvest, mainly because of their high respiration rate and the fact that they have no barrier to protect them from water loss. Mushrooms’ shelf-life is limited to a few days under normal refrigeration conditions, which is a constraint on the distribution and marketing of fresh product, making extension of mushroom’s shelf life a constant quest. Modified atmosphere packaging provides an affordable packaging system that partly avoids enzymatic browning, fermentation and other biochemical processes by maintaining a controlled gas atmosphere. However, modified atmosphere packaging conditions should be carefully designed. Inappropriate modified atmosphere conditions may be ineffective or even shorten the shelf life of the product due to damage of tissues. Preservation techniques and specially use of MAP, specifically for Agaricus, Lentinus edodes and Pleurotus, is reviewed.

Mushrooms were tested for their antibacterial and antifungal properties. Surprisingly, shiitake extract was found to be effective as an antimicrobial substance and was significantly more antibacterial than ciprofloxacin. Polysaccharides extracts of medicinal mushrooms act as natural antioxidants and possess immunomodulatory properties (Kozarski, et al., 2011). Packaging, coating, refrigeration and dipping in sorbitol and CaCl2 dipping (Koushki et al., 2011) are the most common methods used for extending the shelf life of mushrooms (Eissa, 2007). Appropriate packaging can delay development of deterioration and senescence of mushrooms after harvest (Taghizadeh et al., 2010). One alternative to extend mushrooms’ shelf life during postharvest storage and commercialization is modified atmosphere packaging (Koushki et al., 2011; Kim et al., 2006)

The purpose of this paper is to review deterioration, shelf life, nutritional value and use of modified atmosphere packaging for keeping three kind of fresh mushrooms (Agaricus bisporus, Lentinus edodes, and Pleurotus spp) better.

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REFERENCES

1 Button mushroom, White Button Mushroom; WBM
2 Xiang gu in Chinese and shiitake in Japanese
3 Oyster mushrooms
4 Wood ear mushroom
5 Winter mushroom
6 Straw mushroom

2. Koopman and Laney, 2010
3. Koushki et al., 2011
4. Aida et al., 2009
5. Cheung, 2008
6. Koushki et al., 2011
chlorosalicic acid could strongly inhibit both monophenolase activity and diphenolase activity (Han et al., 2008). Mushrooms have a short postharvest shelf life compared to most vegetables, due to a very high metabolic activity and high water content, making them prone to microbial spoilage and to exhibit enzymatic browning. After harvest the mushroom colour gradually changes from white to brown, due to the appearance of browning and possibly bacterial blotching, while the growth of the stipe and the cap continues. The cap growth results in gradual opening of the mushroom cap (Aguirre et al., 2009).

Presence of more than 90% moisture content of mushrooms indicated that, they are highly perishable and start deteriorating immediately after harvest. They develop brown colour on the surface of the cap due the enzymatic action of phenol oxidase, this results in shorter shelf life (Mehtha et al., 2011).

The intact mushrooms lose their commercial value within a few days, due to several factors, such as microbial attack and browning. 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 (Nery 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). The effects of a-cyano-4-hydroxycinnamic acid (HCCA) on the activity of mushroom tyrosinase have been studied. Results showed that HCCA could inhibit both the monophenolase activity and diphenolase activity of mushroom tyrosinase (Qin et al., 2009).

Yi and others in 2009 studied on inhibitory effects of vitamin C esters 1 and 2 on the diphenolase activity of mushroom tyrosinase. The results showed that compounds 1 and 2 inhibited tyrosinase with IC50 values of 0.58 and 0.16 mM, respectively. The dose-response curves demonstrated that compounds 1 and 2 not only lengthened the lag time, but also decreased the steady-state rate. Koulski et al. in 2011 evaluate that MAP in combination of CaCl2 dipping had effective in extending shelf life of the packaged mushrooms. Although Modified atmosphere packaging (MAP) is one of a number of technologies available to control product deterioration, providing an appropriate protective atmosphere and the product (Zhang et al., 2006) and it is a suitable way for mushroom preservation and after some suitable results, in recent years, some researchers study on Integrated application of MAP and other techniques to improve mushrooms quality (Jiang et al., 2011, 2010)

Respiration rate

Short shelf-life of mushrooms is due to their high respiration rate, tendency to turn brown and lack of physical protection to avoid water loss or microbial attack and which is the major cause of quality losses that accounts for reduction in market value (Mohapatra et al., 2008). Therefore, mushrooms need special attention to retain freshness (Kim, 2006). There are several indicators that determine the quality of mushrooms, such as visual appearance, size, colour, maturity stage, development stage, microbial growth and weight loss (Aguirre et al., 2008). The main processes responsible for mushrooms sensory quality loss are browning and texture changes (Ares et al., 2006). The shorter shelf life of mushrooms is due to the increase in respirations rates (CO2 28-243 mg kg-1 fresh weight per hour at 9°C and 280 mg CO2 kg-1 fresh weight per hour at 19°C (Rai and Arumuganathan, 2008).

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Respiration rate of fresh mushrooms under air at 10°C ranges from 17.8 to 178 CO2 kg-1 s-1, depending on mushroom species considered (Ares et al. 2006; Parentelli et al. 2007). Respiration is widely assumed to be slowed down by decreasing available O2 and increasing CO2. Furthermore, if O2 concentrations are too low or CO2 too high physiological damages might occur to the product. Therefore modified atmosphere packages should be carefully designed since a system incorrectly designed may be ineffective or even shorten the shelf life of the product (Ares et al., 2007). The influence of CO2 respiration rate depends on the type and developmental stage of the commodity, CO2 concentrations and time of exposure (Parentelli et al., 2007). Shiitake mushrooms showed a higher respiration rate and a higher susceptibility to high Co2 concentration than other mushrooms varieties (Ares et al., 2006).

Browning

An important cause of loss of Mushroom quality during postharvest storage is browning (Ares et al. 2006; Parentelli et al. 2007). Mushrooms have a short postharvest shelf life compared to most vegetables, due to a very high metabolic activity and high water content, making them prone to microbial spoilage and to exhibit enzymatic browning (Mehtha et al., 2011).

The activity of tyrosinase, responsible for mushroom browning was dependent on O2 concentration (Antmann et al., 2008). Also showed that the relative humidity also affected the transition process from "white" to "brown" and storage of mushrooms in an abused situation produced an increase of the brown spotting from the beginning of the storage which was constant in the entire storage time (Aguirre et al., 2009).

PPOs also known as tyrosinase, catechol oxidase, catecholase, phenolase, monophenol oxidase, and cresolase were discovered first in 1856 in mushrooms. Tyrosinase oxidizes some monophenols to o-diphenols and then the former are oxidized to quinones, which spontaneously polymerize to form brown, black or red pigments (Nery et al., 2006).

Texture changes

One of the main changes associated with mushrooms deterioration are changes in their texture (Ares et al. 2006; Parentelli et al. 2007). Mushroom texture can be affected by various factors like heat treatment and storage in pH ranges and showed that shear force exhibited similar trend to firmness but with distinguishable differences (Caglarirmak, 2007).

Modified atmosphere packaging (MAP)

Modified atmosphere packaging (MAP) is a technique used for prolonging the shelf-life period of fresh or minimally processed foods. In this preservation technique the air surrounding the food in the package is changed to another composition (Sandhya, 2010). The use of modified atmosphere packaging to extend the shelf life of mushrooms has been extensively reported (Sandhya, 2010) and it is one of the most effective and economical ways to maintain freshness (Simón and Gonzalez-Fandos, 2011). Two of the most important factors in determining deterioration rate during modified atmosphere storage are temperature and gas composition (Ares et al., 2007).

Modified atmosphere is created in a sealed package of a fresh horticultural produce as a result of exchange of respiratory gases namely O2 intake and CO2 evolution. When the rate of gas permeation through the packaging material equals respiratory gas exchange, consequently an equilibrium concentration of O2 and CO2 are established (Rai and Arumuganathan, 2008).

One of the primary effects of MAP is a lower rate of respiration, which reduces the rate of substrate depletion. Ethylene (C2H4) is a natural plant hormone and plays a central role in the initiation of ripening, and is physiologically active in trace amounts (0.1 ppm). C2H4 production is reduced by about half at O2 levels of 4% during MAP, but also found that atmospheres with high CO2 concentration had no effect on colour change. Although Colour deterioration was inhibited by storage at 0°C and also showed improvement in quality (Escalona et al., 2006). Recommended gas mixtures for MAP are shown below (Table 1).

Table 1 Recommended gas mixtures for MAP

<table>
<thead>
<tr>
<th>Product</th>
<th>O2%</th>
<th>CO2%</th>
<th>N2%</th>
</tr>
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<tbody>
<tr>
<td>Mushrooms</td>
<td>3-21</td>
<td>5-15</td>
<td>65-92</td>
</tr>
</tbody>
</table>

Mushrooms are conventionally packed in plastic trays over-wrapped with perforated PVC films and stored under refrigeration temperature and also PVC over-wraps were efficient in reducing weight loss, in retaining the vitamin C content and in reducing browning during storage (Mota et al., 2006). MAP (Agaricus bisporus)

In some research showed that storage in 1 or 2% O2 + 0 or 4% CO2 was best in keeping their quality and firmness. High CO2 prevented cap opening at 12°C but also found that atmospheres with high CO2 concentration resulted in more cap browning, although O2 concentration did not have any effect on colour change. Although Colour deterioration was inhibited by storage at 0°C and also showed that atmospheres with high CO2 concentration also found that atmospheres with high CO2 concentration also found that atmospheres with high CO2 concentration caused a ‘yellowing’ of the cap surface. Furthermore 10% CO2 could delay deterioration, but levels of over 10% could cause a ‘pinkish’ discoloration (Thompson, 2010).

MAP (Lentinus edodes)

Sorbitol and sodium chloride were used to modify the in-package relative humidity (IPRH) of fresh mushrooms (water irrigated and CaCl2 irrigated) stored in a modified atmosphere package (MAP) at 12 c. No differences were observed for maturity index and microbial population between mushrooms stored in modified atmosphere package (MAP) with or without moisture absorbers. Normally grown mushrooms with 10 and 15g sorbitol and the best color no improvements in quality were found with moisture absorbers with normally grown mushrooms (Antmann et al. 2008).

Parentelli et al. in 2007 Studied the influence of modified-atmosphere packaging under microbiological and sensory quality of shiitake mushrooms
(Lentinula edodes) mushrooms were packaged under atmospheric air (passive modified atmosphere) and initial gas mixture of 5% O2 and 2.5 % CO2 (active modified atmosphere), in bags of two different films: low-density polyethylene (PE) and polypropylene (PP). Sensory analysis showed that mushrooms stored under modified atmosphere (active and passive) had a higher desirability than those stored in PP macropackaged films and lower sensory quality values during the entire storage time (Parentelli et al., 2007).

MAP (Pleurotus ostreatus)

However, mushrooms such as Pleurotus ostreatus undergo rapidly deterioration during storage and distribution. Many studies on maintaining freshness of mushrooms have been reported on modified atmosphere packaging (MAP), controlled atmosphere (CA), chill storage, coating treatment, radiation treatment, and associate peroxidase (Lee et al., 2007). Passive modified atmosphere packaging of Pleurotus ostreatus stored at 40°C in bags of LDPE, PVC and a microperforated film. After 7 days of storage, the better visual quality was obtained for mushrooms in PVC packages (Ares et al., 2007).

CA storage was shown to have little effect on increasing storage life at either 1.0 or 3.5 °C, but at 8 °C with a combination of 10% CO2:2% O2, 20% CO2:21% O2 or 30% CO2:21% O2 the oyster mushrooms had a reduced respiration rate and retained their quality for longer than those stored in air. Recommended storage at 1°C and 94% RH in 30% CO2:1% O2 was about 10 days, and 5% CO2:1% O2 for 21 days (Thompson, 2010).

Integrated Application of MAP along with other techniques to improve mushrooms quality

In 2008 Cliffe-Birne and O’Beirne studied The effects of different washing treatments combined with modified atmosphere packaging (MAP) on the quality and storage life of sliced mushrooms were determined. There were no additional benefits to the sensory and microbial quality from using a two-stage wash versus a single wash of either H2O2 or CI02 combination antimicrobial/browning treatments using H2O2 and sodium D-isocorbate monohydrate had beneficial effects on quality, with better acceptability of appearance and colour and significant microbial reduction. A spray application of sodium D-isocorbate monohydrate, proved even better than a washing treatment, probably due to minimal water uptake. Spray applications of H2O2 above 1% were damaging. Overall, washing had significant effects on the quality and storage life of MA packaged sliced mushroom.

In 2010 Jiang and others had a research on effect of integrated application of gamma irradiation and MAP on physicochemical and microbiological properties of shiitake mushroom. Shiitake (Lentinula edodes) mushroom is the second most cultivated edible mushroom in the world, comprising of about 25% of the worldwide production. Its production has increased faster than any other mushroom species. Shiitake mushrooms were packed in biorientated polypropylene (BOPP) bags and exposed to different doses of gamma irradiation (1.0, 1.5, and 2.0 kGy) within the packaging, heat sealed and stored at 4 °C for 20 d. Of the three doses, 1.0 kGy was most effective in maintaining a high level of firmness. Samples treated with 1.0 kGy also exhibited smaller initial declines in firmness and further increases in total sugar content and lower levels of malondialdehyde accumulation. Furthermore, 1.0 kGy promoted the accumulation of phenolics compound and showed higher antioxidant activity during storage. At higher doses, 2.0 kGy resulted in a higher microbial reduction, but showed negative effects on texture, chemical properties and functional components. It is evident from this study that integrated treatments of gamma irradiation (1.0, 1.5, and 2.0 kGy) + MAP was more effective in reducing microbial counts than stand-alone MAP.

In another research on effect of integrated application of nitric oxide and modified atmosphere packaging to improve quality retention of button mushroom, ozone treatment and moisture absorber treatment (Lee et al. 2007) showed that ozone treatment in biorientated polypropylene (BOPP) bags, heat sealed and stored at 4 °C for 16 days (d). Mushroom weight loss, firmness, color, percent open caps, total phenolics, ascorbic acid and H2O2 contents, superoxide anion (O2-) production rate and activities of polyphenol oxidase (POO), superoxide dismutase (SOD), catalase (CAT), and ascorbate peroxidase (APX) were measured. The results indicate that treatment with 1 mM DETANO maintained a high level of firmness, delayed browning and cap opening, promoted the accumulation of phenolics, ascorbic acid and reduced the increases in both O2 production rate and H2O2 content. Furthermore, NO inhibited the activity of PPO, and increased the antioxidant enzymes activities of CAT, SOD and APX throughout storage period. Thus it was observed that application of NO in combination with modified atmosphere packaging (MAP) can extend the storage life of button mushroom up to 12 d of storage at 4 °C (Jiang, 2011).

Koushki et al. in 2011 research on Effect of integrated application of CaCl2 dipping and MAP on physiological properties of Agricus bisporus mushrooms. Results show that MAP of 5% CO2: 10% O2 (P2G1) with CaCl2 dipping (0.3% for 5 min) and storage at 4°C can be successfully used for extending the shelf-life of the mushrooms for more than 11 days.

REFERENCES


CAGLARIRMAK, N. 2007. The nutrients of exotic mushrooms (Lentinula edodes and *Pleurotus* species) and an estimated approach to the volatile compounds. *Food Chemistry*, 105,1188-1194.


