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Effect of Packaging Material and Temperature on Firmness of Minimally Processed Button Mushrooms (*Agaricus bisporus*)

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ABSTRACT

Mushrooms (*Agaricus bisporus)* are one of the most perishable horticultural produce with high nutritional value and short shelf life usually 1-3 days at ambient temperature. The market acceptance of mushroom is mainly affected by its colour and firmness. In the current study, experiments were carried out to evaluate the effect of storage conditions on firmness ofminimally processed mushrooms. Mushrooms were packed in polythene bags (a) 100 gauge (b) 200 gauge (c) 300 gauge (with and without macro-perforations)and stored at (i) 13°C (ii) 18°C (iii) 24°C (iv) 4±1 °C (refrigeration temperature) and (v)-18°C (deep freezer). It was observed that the samples packed in 200gauge polythene bags and stored at refrigeration temperature had a longer shelf life due to delayed deterioration in the firmness when compared to mushrooms stored at13,18 and 24˚C.The mushrooms stored at deep freezer (-18˚C) showed a different trend as the firmness increased significantly due to phase change of water present in the produce.

Key Words: Button Mushroom,Packaging, Shelf life, Temperature.

INTRODUCTION

Mushrooms belong to the group of edible fungi and are a rich source of protein. The most commonly grown mushrooms are *Agaricus bisporus* commonly known as white button mushroom. They are highly perishable with high nutritional value and short shelf life of 3-4 days(Lee, 1999) compared to most of the vegetables at ambient temperatures, because they have no cuticle to protect them from physical or microbial attack or water loss (Martine *et al* 2000). The transpiration rate of mushrooms is 2.5mg/cm^2 which is higher than tomato due to absence of protective skin which leads to higher moisture loss (Mahajan *et al* 2008).There is a need to extend the shelf life of the mushrooms for which special handling is required.Minimally processed fruits and vegetables are getting a good response commercially as they have some advantages of cost and labour (Hoover, 1997).

Polythene is the cheapest and most widely used for food packaging in developing countries. It is available in a wide range of thickness and grades, all of which are flexible,relatively tough,heat sealable and transparent.The Low Density Polythene (LDPE) has relatively poor barrier properties in comparison to HDPE (High Density Polythene) 200-500 gauge as they have comparatively better barrier properties against moisture, air and odours. The current study was carried out with an objective to assess the effect of the packaging material and storage temperate on the firmness of freshly harvested minimally processed mushrooms. To investigate the mushrooms were packed in polythene bags (a) 100 gauge (b) 200 gauge (c) 300 gauge (with and without macro-perforations) and stored at (i) 13°C (ii) 18°C (iii) 24°C (iv) 4±1 °C (refrigeration temperature) and (v)-18°C (deep freezer)at atmospheric and sub atmospheric conditions.

MATERIALS AND METHODS

White button mushrooms (*Agaricus bisporus)* were obtained during the first stage of maturity and transported in the refrigerated van to the laboratory within 3 hours of picking. The damaged

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and bruised mushrooms were removed while the sound mushrooms were packed in polythene bags of 200,300,400 gauge (with and without perforations).The area under macro perforations was 1per cent of the total packed area uniformly. The sub atmospheric conditions were created with a vacuum pump, the pipe attached was used to eliminate the air present in the polythene bag and sealed with a sealing machine. These samples were stored at different roomtemperatures (13°C, 18°C, 24°C), refrigeration temperature (4±1° C) and deep freezer(-18±1°C).

Texture

Softening of mushrooms was determined by penetration test using penetrometer(Mc Cormick Fruit Tester FT-327)in the range 0.2-5 kg/cm^2 and 1.5-12 kg/cm^2.The needle of penetrometer was axially inserted through the button portion parallel to stipe. With the uniform application of force, the needle on the dial moved and the reading was recorded as firmness (kg/cm^2). The study was so designed that the initial firmness for a lot under specific storage conditions were taken as constant.

Firmness=Reading on the gauge (kg)/Area of the penetrometer (cm^2)

Statistical Analysis

Experiments were arranged in completely randomized design and each composed of three replicates. Analysis of variance (ANOVA) was computed using statistical program for social sciences (SPSS 13.0) and the differences at $P \leq 0.05$ was considered significant.

RESULTS AND DISCUSSION

Effect of packaging material on the firmness

The initial firmness of mushrooms varied from 3.35kg/cm^2 to 4.95 kg/cm^2.These were packed in polythene bags and stored at constant temperature. The firmness of the mushrooms packed in polythene bags of variable thickness decreased with time.

The parameters had a significant effect on the firmness of the mushroom. The minimum loss of 15.6 per cent in the firmness was recorded for the samples packed in 200 gauge and 12.7 per cent for mushrooms packed in 400 gauge polythene bags with macro pores at atmospheric pressure. The effect of packaging at 13°C under sub atmospheric pressure was non-significant. The bags without macro-perforations showed precipitation of water, the moisture within the package appeared to have

Table 1. Effect of packaging material on the firmness (kg/cm^2)of the mushrooms.

Parameter	Initial	200 gauge	300 gauge	400 gauge	Packaging Material	Shelf Life (d)	CD
3rd Day at 13°C							
AP	3.7	3.12	2.9	2.97	0.41	0.69	0.54
MP	3.7	2.6	2.96	3.23	0.19	0.52	0.34
SAP	3.7	2.82	3.0	2.57	NS	0.63	NS
3rd Day at 18°C							
AP	4.05	2.72	2.35	2.3	0.21	0.89	0.43
MP	4.05	2.62	2.90	2.78	N.S	0.96	NS
SAP	4.05	2.62	2.72	2.57	N.S	0.87	NS
3rd day at 24°C							
AP	4.95	4.35	4.43	4.65	0.66	1.17	0.87
MP	4.95	4.15	4.15	4.18	0.19	1.47	0.61
SAP	4.95	4.35	4.46	4.45	NS	1.23	NS

AP (Atmospheric Pressure),MP (Macro Perforations),SAP (Sub Atmospheric Pressure)

Table 2. Effect of packaging material on the firmness of the mushrooms on the 12th day at Refrigeration Temperature (4± 1 °C)

Parameter	Initial	200 gauge	300 gauge	400 gauge	Packaging Material	Shelf Life(d)	CD
AP	4.95	3.6	3.85	3.36	0.66	1.17	0.87
MP	4.95	2.41	2.23	2.03	0.19	1.47	0.61
SAP	4.95	3.25	2.93	2.90	NS	1.23	NS

AP (Atmospheric Pressure), MP (Macro Perforations), SAP (Sub Atmospheric Pressure)

no effect on the mushroom softening (Beecher *et al* 2001).The condensation rather depends upon the water uptake during cultivation and storage at RH 90-95 per cent (Table 1).

At 18°C the effect of packaging material was non-significant for both the samples stored in polythene bags with macro perforations and samples packed in polythene bags at sub atmospheric conditions. Minimum loss of firmness of 32 per cent was observed for mushrooms stored in polythene bags 200gauge, in comparison to the control (41.6%).

At 24˚C, the effect of packaging material with macro perforations was non-significant. Minimum loss of 14.2 and 14.4 per cent was recorded for the samples packed in 200 and 300 gauge at atmospheric pressure while the control recorded a loss of 41.8 per cent. The mushrooms packed in 200gauge at atmospheric pressure retained the maximum firmness. With the increase in temperature the gradient increased resulting in the transfer of water from the mushrooms to the surroundings. As the temperature increases the loss of water increases and the texture deteriorated at a fast pace. Similar results of water loss and senescence have been reported by Nerya *et al* (2006).

At refrigeration temperature the quality of mushrooms on the 12th day of storage was comparable to the 3rd day at room temperature so the data for that period is reported. Maximum firmness was retained by mushrooms packed in 300 gauge followed by those packed in 200 gauge and 400gauge, respectively at atmospheric conditions. Similarly, the loss in firmness was higher at higher temperature when compared to refrigeration temperature. Similar trend was recorded by Zivanovic *et al* (2000) and it could be attributed to protein and polysaccharide degradation, hyphae shrinkage, central vacuole disruption and expansion of intercellular space at pileal surface. The mushrooms packed under sub atmospheric conditions had a non-significant effect on the packaging material. Comparing the firmness at different room temperatures (13, 18, 24°C) and the refrigerated temperature, it was observed that the firmness decreased in comparison to fresh mushrooms but the deterioration of the samples stored at refrigeration temperature was delayed (Table 2).

A reverse trend was recorded for the samples stored in the deep freezer. Due to low temperature

Table 3. Effect of packaging material on the firmness of the mushrooms on the 8th day at Deep Freezer (-18°C)

Parameter	Initial	200 gauge	300 gauge	400 gauge	Packaging Material	Shelf Life (d)	CD
AP	3.35	5.03	5.53	5.25	1.38	1.22	0.87
MP	3.35	5.3	5.5	5.31	NS	1.37	NS
SAP	3.49	4.39	4.3	5.25	0.18	0.89	0.47

AP (Atmospheric Pressure), MP (Macro Perforations), SAP (Sub Atmospheric Pressure) the water present in the mushroom (bound and unbound) changed from liquid to solid form resulting in the increased firmness. More force was required to penetrate through the pelus. Slow freezing led to the formation of big ice crystals damaging the adjacent cell wall. When these mushrooms were exposed to the room temperature thawing took place and phase change of water from solid to liquid occurred. The ruptured cells lost the turgidity and resulted in poor textural properties making it unacceptable for the market.

It was recorded that temperature had a significant effect when compared with the packaging material. As the temperature increased the texture of the mushroom deteriorated with time. This could be due to increased respiration rate with the time. At room temperature minimum loss in the firmness was recorded for samples packed in 200gauge polythene bags under atmospheric condition and 400 gauge macro perforated polythene bagsat24˚C and 13˚C, respectively.

The macro perforation had a non-significant effect on the in the packaging material and shelf life of the mushrooms. The firmness of samples packed in macro-perforated polythene bags was similar to control due to absence of the barrier to control the water vapor transmission rate. These samples showed similar characteristics of veil opening, turning the gills brown, elongation of the stem and reduced texture (Lopez-Briones *et al* 1992).

The sub-atmospheric conditions created by eliminating the oxygen with the vacuum pump reduced the concentration of oxygen present. The small amount of oxygen present restricted the respiration rate thus reducing the moisture content maintaining the firmer texture, retarded cap development, reduced aerobic deterioration and weight loss. Similar results of decrease in rate of senescence stored in LDPE at 12°C though the concentration of carbon dioxide and oxygen varied were reported by Roy *et al* (1995).It was reported by Martin and Beelman (1996) that less than 2 per cent of oxygen can cause anaerobic microbial growth such as *Clostridium botulinum* and *Staphylococcus aureus*. For the packs stored at sub- atmospheric condition detrimental deterioration was observed, mushrooms with dark brown blotches and opening of the veil. Carbon dioxide concentration higher than 12 per cent causes loss of firmness and an increase in the enzymatic browning of *Agaricus bisporus* due to cell membrane damage. The concentration of carbon dioxide and oxygen is very critical. The degree of sensitivity towards carbon dioxide varies with the type of mushrooms. Excessive carbon dioxide inside the package can cause physiological injuries resulting in severe browning and off flavors (Jacxsens *et al* 2002).

CONCLUSION

The samples stored at refrigeration showed the maximum shelf life for the samples packed in 200gauge polythene bags. The size of the perforations was big which subsided the characteristics of the individual polythene sheet. Small openings uniformly distributed can be considered for further studies. The samples stored in deep freezer showed an increase in the firmness but due to slow freezing the rupture of adjacent cells took place and it destroyed the texture which was prevalent during thawing. Mushroom is highly nutritious horticulture produce and for maximum retention of the nutrients there is a lot of scope in freeze drying of mushrooms.

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