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Full Length Research Paper

Extension of the Shelf-life of Minimal Processed Oyster Mushrooms with Chemical Treatments

Kanagarajah Premakumar[1]*, Sritharan Sahana[2], M. A. Prathibha Malmi Perera[1]

[1]Department of Agricultural Chemistry, Eastern University, Chenkalady, Sri Lanka

[2]Department of Biosystems Technology, Eastern University, Chenkalady, Sri Lanka

*Corresponding author's Email: premakumar.k2016@gmail.com

Abstract

The aim of this research was to evaluate the effect of ascorbic acid, calcium chloride, sodium metabisulfite solution and citric acid on minimal processing and subsequent storage on oyster mushroom quality. The moisture content, pH value, fat content, crude fiber content, protein content and total carbohydrate content were evaluated. Oyster mushrooms were immersed separately in ascorbic acid, calcium chloride, sodium metabisulfite solution & citric acid and stored in 4˚C for two weeks. Results indicated that the sodium metabisulfite treated minimally processed oyster mushroom retained firmness, showed less colour change and taste better, aroma and overall acceptability and was the best compared to other treatments based on physico-chemical, Organoleptic qualities, and storage studies. These storage conditions increased moisture content, and total carbohydrate content in respect to storage period where sodium metabisulfite treatment the extended shelf life of minimally processed oyster mushroom.

Keywords: Oyster mushroom, Sodium metabisulfite, Minimal processed, Shelf life, Storage, Physico-chemical analysis

INTRODUCTION

Sri Lanka needs a continuous supply of good quality, locally cultivated mushrooms. *Pleurotus ostreatus* (Oyster mushroom) is well preferred vegetable for Sri Lankans and as an ingredient in soup because of its high nutritive content, unique flavor, and medicinal properties. Many varieties of mushrooms are consumed throughout the world because of their medicinal properties attributed to their bioactive compounds that present immune modulating, antitumor, antioxidant, radical scavenging, cardiovascular, antibacterial, antiviral, and antihypertensive, ant hypercholesterolemia, detoxification, hepatoprotective, and antidiabetic activities. (Rathee et al., 2012).

The *Pleurotus* genus stands out because of its nutritional composition (0.8-2 g proteins, including 16 different essential amino acids, vitamins, folic acid, minerals, carbohydrates, lipids and a low-calorie content). This composition gives it functional properties, enabling it to be used in treating diseases like hypertension, and it also exhibits antitumoral, anticancer and antiviral activities (Caglarirmak, 2007). These characteristics have increased its demand and consumption in presentations such as frozen, dehydrated, precooked, fresh as a whole product and minimally processed (Carrera et al., 2007). Minimally processed products are an important alternative to encourage consumption of oyster mushrooms. They can be prepared by one or more-unit operations, including sliced or diced products. Preservation treatments include the use of minimal heating, chemical preservatives, radiation, pH control, immersion in chlorinated or electrolyte water, modified atmosphere packaging and maintaining a suitable temperature during a cold chain (2-7 ˚C) (Correa et al., 2016).

Also, fresh mushroom is susceptible for microbial growth due to their high-water activity, high respiration rate, and neutral pH (Carrera et al., 1998) and continuous metabolism after harvest which results in changes in some of its quality parameters such as color, weight, and texture (Okhuoya, 2005). These characteristics limit the postharvest shelf life of fresh mushroom to few days (1–3 days) which is an impediment to their distribution and storage (Ares et al., 2007), hence there is a need of a technology that can be used to preserve the postharvest quality of mushroom while ensuring its safety. Food-grade chemical preservatives such as ascorbic acid, calcium chloride, sodium metabisulfite solution and citric acid have been used within their maximum permissible levels to prolong the shelf life of foods. The aim of this study was to evaluate the effect of ascorbic acid, calcium chloride, sodium metabisulfite solution and citric acid on minimal processing and select chemical preservative(s) that are suitable for extending the shelf life of oyster mushroom.

MATERIALS AND METHODS

This study was undertaken at the Food Science Laboratory of the Department of Agricultural Chemistry, Faculty of Agriculture, and Eastern University, Sri Lanka for a period of five months from January to May 2019.

Raw materials

Undamaged, healthy, sound fresh oyster mushrooms (*Pleurotus* spp.) were harvested under normal commercial conditions from a commercial farm at Mylambaveli, Batticaloa district. Harvested mushrooms were kept on plastic crates and transported to the laboratory. Mushrooms were sorted by size and appearance. Diseased, damaged, and extremely large or small mushrooms were discarded to minimize biological variability. Citric acid, ascorbic acid, calcium chloride, sodium metabisulfite and other all the materials were collected from Food Science Laboratory, Department of Agriculture Chemistry, Eastern University, Sri Lanka

Experimental design

The experiment was laid out in a Completely Randomize Design (CRD). Experiment has four treatments with three replications. Treatments were experimented with minimal processing and divided and soaked in three types of chemical solutions for one minute. As soon as they soaked, those were taken out to avoid water-soaked appearance. After that, mushrooms were dried in air to reduce moisture content to prevent microbial growth. Finally, four treatments of air-dried mushrooms were packed in macro perforated polythene bags. Oyster mushrooms packed in macro perforated polythene bags without soaking in any chemical solution considered as T1, oyster mushrooms packed in macro perforated polythene bags after soaking in citric acid solution as T2, oyster mushrooms packed in macro perforated polythene bags after soaking in ascorbic acid and calcium chloride solution as T3, and oyster mushrooms packed in macro perforated polythene bags after soaking in sodium metabisulfite solution as T4. Then the packets were labeled and stored in refrigerator

Nutritional analysis

All the physico- chemical parameters were analyzed using the recommended AOAC (2002) methods. Moisture content, ash content, pH, protein content, total carbohydrate, Fat, Dietary fiber were analyzed after formulation and the storage period.

Organoleptic qualities analysis

The color, taste, texture, aroma and overall acceptability were evaluated using a Seven –point hedonic scale after formulation.

Storage studies

The four treatments of freshly prepared Minimally Processed Mushrooms samples were subjected for storage studies. They were stored in refrigerator at 4˚C for two weeks period of time. Physico- chemical analysis of the above samples was done at 3 days intervals. Sensory evaluation was done to curry samples prepared from the minimally processed mushrooms stored in a refrigerator for period of 12 days using seven-point hedonic scales after two weeks to evaluate color, taste, texture, aroma and overall acceptability,

RESULTS AND DISCUSSION

Moisture content

Normally mushrooms contain high moisture content ranges from 85% to 95% of their fresh weight (Cheung, 2008) where the results of four treatments ranged from 75.48% to 91.24% reveals the moisture loss may due to the transpiration process and consequently their appearance and texture were affected and also variability is exclusively dependent on the temperature and relative humidity during growth phases (Bano and Rajarathnam, 1988). In this study, oyster mushrooms soaked in ascorbic acid and calcium chloride solution (T3) showed moisture content of about 75.48% (Table 1). This behavior could be due to the high-water content that is usually present in this horticultural product. Also, minimal processing increases the exposed area of the product, resulting in greater dehydration. Das et al., 2010 observed 90% weight loss in P. *Florida* after 7 days storage at ambient conditions.

Table 1: The moisture content, pH, fat content, fiber content, protein content, total carbohydrate content of Minimally Processed Oyster Mushrooms with different treatments.

Treatment	Moisture Content (%)	pH	Fat Content (%)	Fiber Content (%)	Protein Content (%)	Total Carbohydrate Content (%)
T1	91.24±0.203[a]	5.83±1.013[b]	1.20±1.149[d]	31.70±1.451[a]	27.27±0.907[a]	20.33±0.955[b]
T2	85.19±1.321[a]	4.52±0.903[d]	2.43±0.585[b]	18.32±0.784[c]	20.79±0.805[c]	17.96±1.270[c]
T3	75.486±0.066[b]	5.14±1.287[c]	1.71±0.398[c]	11.99±0.727[d]	22.31±1.312[b]	25.53±0.916[a]
T4	90.79±0.195[a]	6.12±0.707[a]	3.49±1.475[a]	26.07±0.864[b]	26.06±0.897[a]	18.23±0.794[c]

The values are means of triplicates ± standard error.

The means with the same letters are not significantly different at 5% level.

Oyster mushrooms packed in macro perforated polythene bags without soaking in any chemical solution considered as T1, oyster mushrooms packed in macro perforated polythene bags after soaking in citric acid solution as T2, oyster mushrooms packed in macro perforated polythene bags after soaking in ascorbic acid and calcium chloride solution as T3, and oyster mushrooms packed in macro perforated polythene bags after soaking in sodium metabisulfite solution as T4.

P^{H}

Table 1 shows the results for pH of the treated mushrooms. There was significance (p<0.05) differences among various chemical treatments. Sodium metabisulfite treated oyster mushroom (T4) had highest score and citric acid treated oyster mushroom (T2) had lowest on the day of preparation showed that the higher acidity, lower the pH of mushroom sample where citric acid treated oyster mushroom had a low pH because, acidity of citric acid lowers the pH of mushroom sample and higher the pH as sodium metabisulfite increased the pH value of sample (T4).

Fat content

The fat contain is generally low (usually <10% dw), Cultivated mushrooms are mainly a source of unsaturated fatty acids (FAs), accounting 75% (w/w) of the total FAs (Diamantopoulou and Philippoussis, 2015). Results indicated that significant differences (P < 0.05) were due to the use of chemical treatments (Table 1). Fat content of the minimally processed mushrooms ranged from 1.2% to 3.49% for all treatments. Sodium metabisulfite treated oyster mushroom (T4) represented highest fat content than chemically untreated mushrooms (T1) attest chemical treatment has not influenced the fat content of the oyster mushroom.

Fiber content

In general, mushroom fruiting bodies are a good source of dietary fiber, comprising mainly water-insoluble fiber in the form of chitin (polymer of N-acetyl-glucosamine) and non-starch polysaccharides like β-glucans (Sadler, 2003). Significant differences (P < 0.05) were observed due to the effect of chemical treatment in fiber content (Table 1). In our study, highest fiber content (31.7%) was recorded with chemically untreated oyster mushrooms. Treated samples were shown a notable fiber loss due to the chemical treatments. Although, sodium metabisulfite treated oyster mushroom (T4) represented considerably good amount of fiber content 26.07% among chemically treated mushrooms.

Protein content

Mushroom proteins are relatively rich in the amino acid, glutamic acid (12.6%–24.0%), aspartic acid (9.10%–12.1%), and arginine (3.70%–13.9%) but deficient in sulfur-containing amino acids, including methionine and cysteine (Cheung, 2008). Mushroom proteins are similar in quality as animal protein. The protein content changed significantly (p<0.05) with the various chemical treatments as shown in the Table 1. Protein content of the minimally processed oyster mushrooms ranged from 20.79 to 27.27. Higher protein content was obtained in chemically untreated mushrooms (T1) and sodium metabisulfite treated mushrooms (T4) pronounced chemical treatment had no adversely affect on protein content of oyster mushrooms

Total carbohydrate

The total carbohydrate content of mushrooms (35%-70%, including digestible and non-digestible carbohydrates), varies with species (Cheung, 2008) which are low in calories. There was significant difference (p<0.05) in total carbohydrate content among various chemical treatments (Table 1). Total carbohydrate content of minimally processed oyster mushrooms ranged from 17.96% to 25.53%. Comparing with the treatment (T1), oyster mushrooms soaked in citric acid solution (T2) and sodium metabisulfite treated mushrooms (T4) had lower scores but oyster mushrooms soaked in ascorbic acid and calcium chloride solution (T3) had an increment in total carbohydrate.

Sensory qualities

The sensory evaluation of the minimally processed oyster mushroom revealed that, there were significant differences between the chemically treated mushrooms for color, taste, texture, aroma and overall acceptability at 5% level of significance shown in Table 2. The highest mean value (6.6) was obtained for sodium metabisulfite treated oyster mushrooms citric acid treated oyster mushrooms attained low due to preference of the consumers about quality in the mushroom influence whiteness. Among chemically treated mushrooms, Sodium metabisulfite treated mushrooms (T4) got most preferable taste where citric acid and ascorbic acid treated mushrooms showed sour taste due to acid treatment. Sodium metabisulfite treated mushrooms (T4) had maximum mean value of 6.8 and citric

Table 2: Sensory Evaluation of Freshly Prepared Minimally Processed Oyster Mushrooms

Treatment	Colour	Taste	Texture	Aroma	Overall Acceptability
T_1	6.4±0.594^{a}	5.2 ±0.810^{ab}	6.4 ±0.692^{a}	6.6 ±0.738^{a}	6.0 ±1.195^{a}
T_2	3.0±1.328^{b}	2.8 ±1.517^{b}	1.8 ±1.058^{c}	1.8 ±1.128^{c}	1.4 ±0.925^{c}
T_3	4.6±1.236^{b}	5.2 ±0.965^{ab}	4.2 ±1.385^{b}	4.0 ±1.348^{b}	4.6 ±0.925^{b}
T_4	6.6±0.594^{a}	6.8 ±0.331^{a}	6.4 ±0.692^{a}	6.8 ±0.603^{a}	6.6 ±0.925^{a}

The values are means of 20 replicates ± standard error.
The means with the same letters in same column are not significantly different from each other at 5% level.

acid treated mushrooms had minimum mean value of 2.8 for taste. Sodium metabisulfite treated mushroom had the highest mean score (6.8) had preferable aroma and citric acid treated mushroom had least mean score (1.8) got unpleasant acidic aroma. Sodium metabisulfite treated oyster mushroom showed best results for taste, color, texture, aroma and overall acceptability.

Oyster mushrooms packed in macro perforated polythene bags without soaking in any chemical solution considered as T1, oyster mushrooms packed in macro perforated polythene bags after soaking in citric acid solution as T2, oyster mushrooms packed in macro perforated polythene bags after soaking in ascorbic acid and calcium chloride solution as T3, and oyster mushrooms packed in macro perforated polythene bags after soaking in sodium metabisulfite solution as T4.

Storage studies

Moisture content

In all treatments, moisture content significantly ($p<0.05$) increased throughout the storage period and reaching a maximum value of 96.32% was in chemically untreated mushrooms (T1) at the end of day 12 storage period. Minimum moisture content value 75.48%. Was with T3 (Ascorbic acid treated mushrooms). It (Figure 1) reveals that the moisture content gradually increased during storage may due to the respiration of mushrooms which is characterized by maintaining high relative humidity inside the packaging. This condition avoids tissue dehydration (Powrie and Skura, 1991). Compared to chemically untreated mushrooms, because of applied chemical, there is weight loss in oyster mushrooms was due to the transpiration process and consequently their appearance and texture were affected.

pH

The results (Table 3) indicated that the pH decreased in minimally processed mushrooms with increased duration of storage pronounced with the maximum pH reduction from 6.43 to 5.77 in chemically untreated mushrooms(T1) in twelve-day time period and also chemically treated mushrooms also signified little reduction in pH. The reason for the decrease in pH might be due to the production of CO_2 as result of Respiration, producing bicarbonate reacting with water lowers the pH of sample during the storage period.

Oyster mushrooms packed in macro perforated polythene bags without soaking in any chemical solution considered as T1, oyster mushrooms packed in macro perforated polythene bags after soaking in citric acid solution as T2, oyster mushrooms packed in macro perforated polythene bags after soaking in ascorbic acid and calcium chloride solution as T3, and oyster mushrooms packed in macro perforated polythene bags after soaking in sodium metabisulfite solution as T4.

Fat Content

In all treatments, fat content was significantly ($p<0.05$) reduced throughout the storage period and reaching minimum value with chemically untreated mushrooms at the end of storage period shown in Figure 2. The reason for slight reduction in fat content of mushrooms might be due to the hydrolysis of fatty acids during storage period of mushrooms.

Crude Fiber Content

In all treatments, fiber content significantly ($p<0.05$) reduced in mushrooms throughout the storage period of twelve

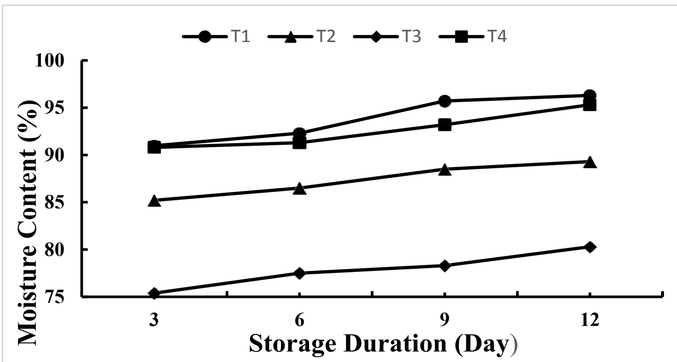

Figure 1: Changes in Moisture Content of Minimally Processed Oyster Mushrooms during Storage.

Table 3: Changes in pH of Minimally Processed Oyster Mushrooms during Storage.

Storage Duration (Days)	T1	T2	T3	T4
3	6.43±0.887[a]	4.42±1.370[d]	5.21±0.768[c]	6.14±0.861[b]
6	6.10±1.884[a]	4.41±0.543[c]	5.19±0.087[b]	6.12±0.379[a]
9	5.83±1.013[b]	4.40±0.903[d]	5.17±1.287[c]	6.12±0.707[a]
12	5.77±1.562[b]	4.40±1.093[d]	5.14±0.372[c]	6.10±0.473[a]

days shown in Figure 3. Minimally processed mushrooms and chemically untreated mushrooms showed reduction in its fiber content. The reason for slight reduction in crude fiber content of mushrooms might be due to hydrolysis of crude fiber materials during storage period of mushrooms. Reduction of fiber content was very low and it was not significant.

Protein Content

The results indicated that the protein content decreased in minimally processed mushrooms with increased duration of storage. Maximum protein reduction was observed (Figure 4) in the chemically untreated mushrooms (T1) from 27.2 to 21.5 and sodium metabisulfite treated mushrooms (T4) had minimum reduction of protein content from 26.0 to 25.5 in twelve days of storage period. Chemically untreated minimally processed mushrooms also showed little reduction of protein content. The reason for the decrease in protein content might be due to the hydrolysis of polypeptides. But minimally processed mushrooms represent very minute reduction of protein content due to chemical treatment.

Total Carbohydrate

In all treatments, total carbohydrate content significantly ($p<0.05$) increased (Figure 5) in mushrooms throughout the storage period of 12 days. Considering the reduction in other nutrients amount in minimally processed mushrooms, total carbohydrate content showed little improvement.

Organoleptic qualities

In this investigation organoleptic scores were decreased gradually with increase in storage period in refrigeration. Temperature plays an important role in biochemical changes that leads to development of off flavor and off odors as well as discolorations in mushrooms. Reduction in

Organoleptic quality is obvious during storage. The Organoleptic scores of sensory evaluations after 12 days of storage are given in the Table 4

Sodium metabisulfite treated mushrooms (T4) had highest mean value. Tyrosinase, commonly known as phenol oxidase (monophenol monooxygenase) is responsible for post-harvest browning of mushrooms causing discoloration in mushrooms. And also, storage period diminishes the taste of mushrooms attributed to deterioration of nutrients of mushrooms where, sodium metabisulfite treated mushrooms (T4) had highest score (6.0) and least mean value was observed in (T2) citric acid treated mushrooms. This reveals taste of ascorbic acid treated mushroom was better than citric acid treated mushrooms. Sodium metabisulfite treated mushrooms (T4) showed best for

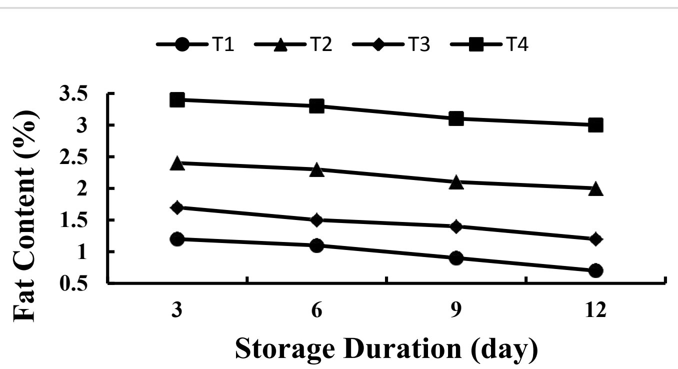

Figure 2: Variations in Fat Content of Minimally Processed Oyster Mushrooms during Storage.

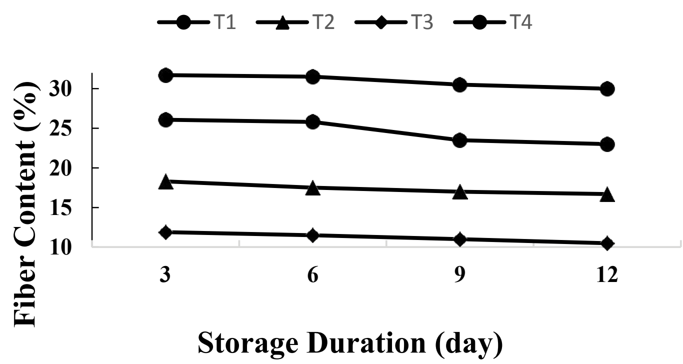

Figure 3: Changes in Crude Fiber Content of Minimally Processed Oyster Mushrooms during Storage.

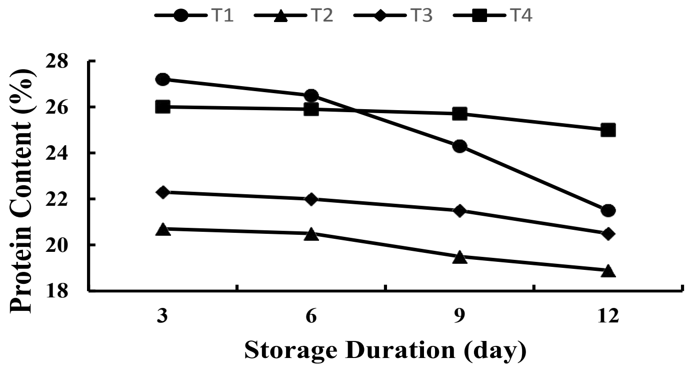

Figure 4: Changes in Protein Content of Minimally Processed Oyster Mushrooms during Storage.

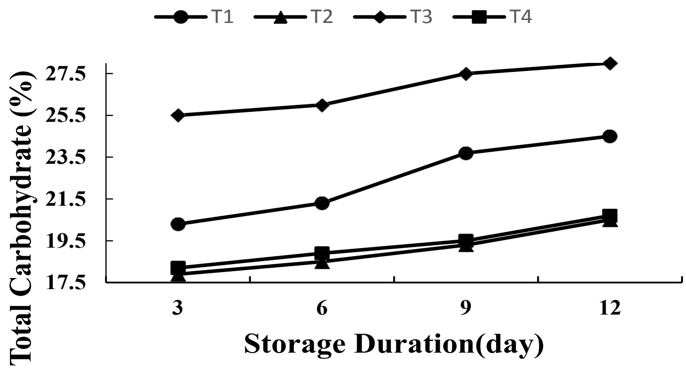

Figure 5: Changes in Total Carbohydrate Content of Minimally Processed Oyster Mushrooms during Storage.

Table 4: Sensory Evaluation of Minimally Processed Oyster Mushrooms after 12 days of storage in a Refrigerator.

Treatments	Colour	Taste	Texture	Aroma	Overall Acceptability
T1	4.66±1.002[b]	4.80±0.982[ab]	4.50±0.873[b]	4.50±0.942[ab]	4.50±1.032[b]
T2	1.33±1.002[c]	1.00±0.001[c]	1.25±0.816[c]	1.00±0.001[c]	1.00±0.001[d]
T3	3.33±1.002[b]	3.83±1.531[b]	2.00±1.333[c]	3.75±1.563[b]	3.00±1.460[c]
T4	6.66±1.002[a]	6.00±0.830[a]	6.25±0.816[a]	5.75±0.816[a]	6.25±0.894[a]

The values are means of 20 replicates ± standard error.

The means with the same letters in same column are not significantly different from each other at 5% level

texture and some samples represent sticky texture and this texture deterioration may occurred due to microbial growth in treated mushrooms. Aroma of ascorbic acid treated mushrooms was better than citric acid treated mushrooms. And the decrease in aroma during storage could be possibly due to the growth of microbial population of mushrooms. There was a slight but significant ($p<0.05$) reduction in the overall acceptability scores of minimally processed mushrooms tally highest in taste, color, texture, aroma and overall acceptability sodium metabisulfite treated mushrooms (T4) than other treatments after 12 days of storage period in a refrigerator.

Oyster mushrooms packed in macro perforated polythene bags without soaking in any chemical solution considered as T1, oyster mushrooms packed in macro perforated polythene bags after soaking in citric acid solution as T2, oyster mushrooms packed in macro perforated polythene bags after soaking in ascorbic acid and calcium chloride solution as T3, and oyster mushrooms packed in macro perforated polythene bags after soaking in sodium metabisulfite solution as T4.

CONCLUSION

Minimally processed treated with sodium metabisulfite oyster mushroom is the best for maintaining the physico-chemical and Organoleptic qualities with an extended shelf life, which has no harmful effects for consumers. Even though permissive levels of sodium Meta bisulfate (400ppm) are recommended as people with asthma have a greater chance of having an allergic reaction to sodium metabisulfite. Minimally processed oyster mushroom is a new product for improving the storage capacity of mushrooms. Minimal processing enhanced the shelf life of mushrooms, reduced the post-harvest losses and reduces the perishability & deterioration rate of mushrooms. Because of their fresh nature, minimally processed mushrooms provide convenience to the user.

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