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RESEARCH ARTICLE

Effect of Chitosan-Lemongrass Essential Oil-Xanthan Gum Coating on the Shelf Life of White Mushroom (*Pleurotus ostreatus*)

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Abstract

Mushrooms (*Pleurotus ostreatus*) are rich in nutrients, such as minerals, vitamins, amino acids, carbohydrate. They have thin and porous epidermal structure with high respiration rate comparing to other fruits and vegetable. They are highly perishable and lose quality very quickly right after harvesting. Mushroom shelf-life is usually short under normal handling and distribution. Therefore, mushrooms must be taken care to maintain their freshness and commercial value. Chitosan has been found to be non-toxic, biodegradable, biofunctional, biocompatible, antimicrobial and antifungal activities. Lemongrass essential oil has stability properties of water vapor permeability of films made based on chitosan. Xanthan gum is one biopolymer promising for food packaging. Our present research focused on the effect of chitosan-lemongrass essential oil-xanthan gum coating on the shelf life of white mushroom (*Pleurotus ostreatus*). Results revealed that a composite of chitosan-lemongrass essential oil-xanthan gum coating (2.0%: 2.5%: 2.0%) could maintain the quality and extend the shelf-life of mushroom for 7 days of storage.

Keywords: *Pleurotus ostreatus, chitosan, lemongrass essential oil, xanthan gum, coating, shelf-life*

Introduction

Mushroom (*Pleurotus ostreatus*) is highly perishable under ambient storage. It has various nutritional components, including bioactive elements, and polysaccharides (such as mannose and trehalose), antioxidants, dietary fiber, ergosterol, vitamin B1, B2 and C, folates, niacin and minerals. Owing to its high respiration rate, its rapid postharvest degradation and quality retention are the key economic issue [1].

After only 1 day of storage at ambient temperature, the cap was opened and colored, stem was elongated, and texture became soft and spongy, resulting in shortening the shelf-life of mushroom [2]. There are several parameters that measure the mushroom quality such as whiteness, cap development, stripe elongation, ripe spore, texture, respiration rate, mannitol content, weight loss and microbial deterioration [3]. There are several studies to extend the shelf-life of mushrooms such as modified atmosphere packaging (MAP) [4, 6], controlled atmosphere storage [3], coating [7, 9], sorbitol [4].Chitosan, a linear polysaccharide consisting of (1, 4)-linked 2-amino-deoxy-ß-D-glucan, is a deacetylated derivative of chitin. Chitosan as an edible coating has been used in the storage of agricultural commodities. After coating with chitosan, surface of post-harvest product is sinny. The respiration rate and weight loss rate are controlled with higher firmness.

Moreover, protective enzyme the activities are maintained at higher level and the cell membrane are nearly intact. Apart from that, chitosan coating has other preventive effects against microorganism to limit decay. By this effectiveness, more phytonutrients are also reserved [10]. Lemongrass (*Cymbopogon citratus*) is a perennial herb, with a strong lemon-like aroma [11]. Wannissorn et al [12].Reported that citral is the main active component of lemongrass oil, giving it a

characteristic odor [13]. Lemongrass essential oil (LMO) and its main component, citral, are hydrophobic compounds and show antimicrobial activity against enterohemorrhagic *E. coli* O157:H7 which is comparable to the effect observed for oregano oil and only surpassed by thyme oil [14]. Lemongrass essential oil can be considered as suitable substitutes for chemical additives for use in the food industry due to their antimicrobial properties [15] and the tendency to replace synthetic antifungal agents [16, 17, 9].

Combining edible coating and essential oils receives a lot of interest today. This combination offers double benefits; first, the coatings help to limit the respiration process, reduce a weight loss during storage; second, this method helps to reduce the amount of essential oil used while their antifungal effects are maintained [18], limit a sensory impact caused by essential oils. *Cymbopogon citratus* has been added in formulations of chitosan films [19].

Xanthan gum, synthesized as an exopolysaccharide by *Xanthomonas campestris*, its use as a stabilizer, thickener or emulsifier. It forms a highly viscous solution in cold or hot water at low concentration with excellent stability over a wide range of pH and temperature and it is also resistant to enzymatic degradation [20]. The effect of xanthan gum coating was studied on minimally processed prickly pear [21], fresh-cut apples [22, 23], mushroom [24].

There were several studies mentioned to the application of coating to prolong mushroom shelf-life during preservation. Effect of modified atmosphere packaging on the shelf-life of coated, whole and sliced mushrooms was examined. The whiteness of whole mushrooms varied significantly with the type of coating [5].

The effect of chitosan coating in fresh-cut mushroom preservation, including microbiological, enzyme activities, color characteristics and chemical quality attributes, was examined. Fresh-cut mushrooms were treated with aqueous solution of 0.5, 1 and 2 g chitosan/100 mL, placed in polyethylene bags, and then stored at 4C. Application of chitosan coating delayed discoloration associated with reduced enzyme activities of polyphenoloxidase, peroxidase, catalase, phenylalanine ammonia lyase and laccase, as well as lower total phenolic content. Also, it reduced enzyme activities of cellulase, total amylase and α-amylase. Microbiological development of the fresh-cut mushroom treated with chitosan coating was also inhibited compared to the control [8].

The effect of chitosan-oil coating on the postharvest quality and shelf life of shiitake (*Lentinus edodes*) mushrooms stored at 4 ± 1°C for 16 days was investigated. The results indicate that treatment with chitosan-oil coating maintained tissue firmness, inhibited increase of respiration rate, and reduced microorganism counts, such as yeasts and molds and pseudomonad, compared to control treatment.

The efficiency was better than that of thyme oil treatment or chitosan coating. Shiitake mushrooms treated with chitosan-oil coating also exhibited significantly higher levels of total phenolics, flavonoids, as well as individual phenolic compounds than control. Sensory evaluation proved the efficacy of chitosan-oil coating by maintaining the overall quality of shiitake mushroom during the storage period [9].

Freshness of mushrooms (*Agaricus bisporus*) was related to the internal atmosphere composition during modified atmosphere packaging (MAP) experiments using polyvinyl chloride (PVC) wrap, polyethylene-1 (PE-1) and PE-2 films. The whiteness of whole mushrooms varied significantly with the type of coating (chitosan and $CaCl_2$), but not with the type of packaging films.

It was evident that the extent of darkening in whole mushroom was greater than in sliced ones after coated. PE-2 packaging combined with coating treatment was the most effective to improve the preservation of mushrooms stored at 12 °C up to 7 days and satisfy consumer acceptance [23].

In the present study, we focused on the application of power ultrasound to treat crushed red dragonfruit pulp, to look for an increase of alcohol content, a reduction of the maceration time needed for the extraction of phenolic and volatile compounds in its winemaking. The effect of chitosan (CH) (1%) along with guar gum (GG) (5, 15, and 25%) on the quality of shiitake mushroom

(*Lentinus edodes*) stored at 4 ± 1 °C for 16 days was investigated [24]. In our current research, we examined the effect of chitosan-lemongrass essential oil-xanthan gum coating on the shelf life of white mushroom (*Pleurotus ostreatus*) during 7 days of preservation.

Materials and Method

Material

Mushrooms were collected from Can Tho city, Vietnam. After collecting, they must be conveyed to laboratory within 2 hours. Chitosan, commercial grade, deacetylation greater than 80% and less than 0.5% insoluble material; lemongrass essential oil, xanthan gum, acetic acid were acquired from Van Dai Phat Co. Ltd.

Researching Procedure

Mushrooms were coated a composite prepared by different formular (chitosan %: lemongrass essential oil %: xanthan gum %) as follow: N1 (1.5%: 1.5%: 2.0%), N2 (2.0%: 1.5%: 2.0%), N3 (2.5%: 1.5%: 2.0%), N4 (2.0%: 2.0%: 2.0%), N5 (2.0%: 2.5%: 2.0%), N6 (2.0%: 2.0%: 2.5%), N7 (2.0%: 2.0%: 3.0%). In order to verify the optimal coating formula, samples were daily taken to analyze weight loss, firmness, total plate count and sensory score during 7 days of storage at normal ambient temperature.

Physico-chemical and Biological Analysis

Weight loss was determined by measuring the weight change during storage by the original weight. Weight was measured on day 0 and day 7 of storage. Firmness (N) was determined by penetrometer. Total plate count (cfu/g) of treated mushroom was numbered by 3M-Petrilm. Sensory score was evaluated by a group of 12 members using 9 point-Hedonic scale.

Statistical Analysis

The experiments were run in triplicate with three different lots of samples. Data were subjected to analysis of variance (ANOVA) and mean comparison was carried out using Duncan's multiple range test (DMRT). Statistical analysis was performed by the Stat graphics Centurion XVI.

Result & Discussion

Weight Loss (%) of Coated Mushroom during Preservation

The reason causing weight loss of post-harvest mushroom is transpiration and the substrate consumption of respiration. After water loss, the textures of mushroom turn soft from crisp. Their taste decreases, and their resistant ability against physical and microbial damage also come down [25]. After coating with chitosan on the surface of fruit and vegetable, more water in the tissue of fruit and vegetable were reserved [26, 27]. Thus, good character and commercial value of post-harvest fruit and vegetable are effectively maintained. Aerobic respiration is essential for post-harvest agricultural products to maintain their own character.

The nutrients are consumed as substrate in respiration. A decline nutrient and commercial value happen. Properly limiting the respiration rate is very important to prolong the shelf life of post-harvest agricultural product [28]. In our experiment, weight loss (%) of coated mushroom during preservation was presented in table 1. It's clearly concluded that formula N5 (2.0%: 2.5%: 2.0%) was appropriated for coating of mushroom.

Table 1: Weight loss (%) of coated mushroom by different formula during preservation

Storage (day)	N1	N2	N3	N4	N5	N6	N7
0	0	0	0	0	0	0	0
1	2.19±0.03^{a}	2.03±0.00^{ab}	2.01±0.02^{b}	1.91±0.01^{bc}	1.86±0.03^{d}	1.89±0.01^{c}	1.87±0.00^{cd}
2	2.35±0.01^{a}	2.28±0.02^{ab}	2.25±0.00^{b}	2.03±0.00^{bc}	1.99±0.02^{d}	2.01±0.00^{c}	2.00±0.03^{cd}
3	2.48±0.00^{a}	2.39±0.01^{ab}	2.31±0.00^{b}	2.15±0.03^{bc}	2.07±0.01^{d}	2.12±0.03^{c}	2.09±0.02^{cd}
4	2.69±0.02^{a}	2.57±0.03^{ab}	2.50±0.01^{b}	2.31±0.04^{bc}	2.20±0.00^{d}	2.26±0.04^{c}	2.23±0.03^{cd}
5	2.82±0.00^{a}	2.72±0.04^{ab}	2.65±0.03^{b}	2.64±0.01^{bc}	2.49±0.02^{d}	2.53±0.01^{c}	2.51±0.01^{cd}
6	2.97±0.03^{a}	2.86±0.02^{ab}	2.81±0.00^{b}	2.73±0.00^{bc}	2.57±0.03^{d}	2.64±0.00^{c}	2.62±0.00^{cd}
7	2.05±0.02^{a}	2.94±0.03^{ab}	2.88±0.02^{b}	2.87±0.02^{bc}	2.71±0.01^{d}	2.78±0.02^{c}	2.74±0.02^{cd}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%)

The chitosan film thickness should be suitable. The permeability cannot be effectively adjusted if the coating is too thin, or the CO_2 was accumulated if the film is too thick. And high concentration of CO_2 may cause anaerobic respiration generating ethanol to damage product tissue. One study evaluated the effectiveness of edible coating using chitosan with lemongrass and thyme essential oils to improve the quality and extending the shelf life of strawberries during storage. Edible coating reduced weight loss and delayed the change in anthocyanin content and microbiological growth. The results showed that coatings maintained firmness, total acidity, ascorbic acid and overall acceptability of strawberry fruits [29].

Firmness (N) of Coated Mushroom during Preservation

Firmness is an important sensory characteristic of agricultural product. The cell membrane plays an important role in maintaining cell structure and function of mushroom. Important parameters of cell membrane integrity are permeability and malonaldehyde. The cell membrane permeability increases once being damaged, causing the electrolyte leakage rate to increase [30]. Malonaldehyde, one of final products in lipid peroxidation reaction, can severely harm cell membrane. During post harvest, their firmness will decrease due to water evaporation, pectin degradation, nutrient consumption [31].

Much free radical in the cell accumulates and harms to cell membrane. Chitosan coating can control the transpiration, and then more water is maintained. The product cell reserves the larger swelling pressure and higher firmness [32]. After coating with chitosan, the increase of the cell membrane permeability and MDA content can be restrained [10].In our experiment, firmness (N) of coated mushroom during preservation was presented in Table 2. It's clearly concluded that formula N5 (2.0%: 2.5%: 2.0%) was appropriated for coating of mushroom.

Table 2: Firmness (N) of coated mushroom by different formula during preservation

Storage (day)	N1	N2	N3	N4	N5	N6	N7
0	2.46±0.03^{a}	2.46±0.03^{a}	2.46±0.03^{a}	2.46±0.03^{a}	2.46±0.03^{a}	2.46±0.03^{a}	2.46±0.03^{a}
1	1.95±0.02^{d}	2.07±0.03^{cd}	2.11±0.01^{c}	2.24±0.03^{bc}	2.41±0.01^{a}	2.31±0.03^{b}	2.37±0.03^{ab}
2	1.84±0.00^{d}	1.99±0.01^{cd}	2.03±0.02^{c}	2.13±0.01^{bc}	2.35±0.00^{a}	2.24±0.01^{b}	2.31±0.01^{ab}
3	1.75±0.01^{d}	1.91±0.02^{cd}	1.95±0.01^{c}	2.05±0.02^{bc}	2.29±0.02^{a}	2.15±0.00^{b}	2.27±0.00^{ab}
4	1.68±0.03^{d}	1.84±0.01^{cd}	1.87±0.02^{c}	1.99±0.00^{bc}	2.21±0.03^{a}	2.04±0.02^{b}	2.22±0.02^{ab}
5	1.59±0.02^{d}	1.75±0.00^{cd}	1.79±0.01^{c}	1.88±0.02^{bc}	2.14±0.01^{a}	1.98±0.00^{b}	2.17±0.00^{ab}
6	1.50±0.00^{d}	1.68±0.03^{cd}	1.68±0.03^{c}	1.79±0.01^{bc}	2.07±0.02^{a}	1.83±0.01^{b}	2.12±0.01^{ab}
7	1.42±0.01^{d}	1.57±0.02^{cd}	1.61±0.00^{c}	1.70±0.03^{bc}	2.00±0.00^{a}	1.74±0.00^{b}	2.03±0.03^{ab}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%)

In vitro studies indicated that the essential oils lemongrass (LO) inhibited the growth of *Colletotrichum gloeosporioides*. the naturally infected avocado cultivars from LO + MAP treatment significantly reduced the incidence of anthracnose, gray pulp, vascular browning, weight loss, loss of fruit firmness and showed acceptable taste, flavor, texture and higher overall acceptance after ripening at 25^{o}C followed by cold storage at 10^{o}C for 18 days [33].

Total Plate Count (cfu/g) of Coated Mushroom during Preservation

The post-harvest mushrooms are vulnerable by spoilage microorganisms, and lead to decay. After chitosan coating, microbes has less chance to contact mushrooms, thus making tem free from microbe's invasions [34]. Even if the coated mushroom is infected, disease incidence is greatly reduced [35].After coating mushroom with chitosan, respiration rate would be decreased. Free radicals also reduced, and the disease resistance could be noted significantly.

Nutritional composition such as soluble solid, polyphenol, vitamin c and flavone are preserved in utmost level [36]. In our experiment, total plate count (cfu/g) of coated mushroom during preservation was presented in table 3. It's clearly noted that formula N5 (2.0%: 2.5%: 2.0%) was appropriated for coating of mushroom.

Table 3: Total plate count (cfu/g) of coated mushroom by different formula during preservation

Storage (day)	N1	N2	N3	N4	N5	N6	N7
0	$6.78x10^{6a}$	$6.78x10^{6ab}$	$6.78x10^{6b}$	$6.78x10^{6bc}$	$6.78x10^{6d}$	$6.78x10^{6c}$	$6.78x10^{6cd}$
1	$3.12x10^{6a}$	$2.71x10^{6ab}$	$1.03x10^{5b}$	$9.43x10^{5bc}$	$1.57x10^{5d}$	$6.45x10^{5c}$	$4.22x10^{5cd}$
2	$1.87x10^{6a}$	$9.82x10^{5ab}$	$7.95x10^{5b}$	$6.21x10^{5bc}$	$7.59x10^{4d}$	$3.73x10^{5c}$	$1.45x10^{5cd}$
3	$7.85x10^{5a}$	$6.54x10^{5ab}$	$4.32x10^{5b}$	$3.79x10^{5bc}$	$4.12x10^{4d}$	$1.25x10^{5c}$	$8.79x10^{4cd}$
4	$4.79x10^{5a}$	$3.57x10^{5ab}$	$1.86x10^{5b}$	$8.97x10^{4bc}$	$1.27x10^{4d}$	$6.40x10^{4c}$	$5.71x10^{4cd}$
5	$2.15x10^{5a}$	$1.04x10^{5ab}$	$9.17x10^{4b}$	$6.42x10^{4bc}$	$8.56x10^{3d}$	$3.19x10^{4c}$	$1.98x10^{4cd}$
6	$8.24x10^{4a}$	$6.86x10^{4ab}$	$5.33x10^{4b}$	$2.19x10^{4bc}$	$4.34x10^{3d}$	$1.85x10^{4c}$	$8.32x10^{3cd}$
7	$5.46x10^{4a}$	$4.53x10^{4ab}$	$2.38x10^{4b}$	$1.03x10^{4bc}$	$2.18x10^{3d}$	$8.77x10^{3c}$	$5.39x10^{3cd}$

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

The effects of different concentrations (0.1%, 0.3% and 0.5%, w/v) of lemongrass essential oil incorporated into an alginate-based [sodium alginate 1.29% (w/v), glycerol 1.16% (w/v) and sunflower oil 0.025% (w/v)] edible coating on the respiration rate, physico-chemical properties, and microbiological and sensory quality of fresh-cut pineapple during 16 days of storage (10 ± 1 °C, 65 ± 10% RH) were evaluated.

The results show that yeast and mould counts and total plate counts of coated samples containing 0.3 and 0.5% (w/v) lemongrass were significantly ($p < 0.05$) lower than other samples [37]. Cassava starch-based edible coating incorporated with lemongrass essential oil (1%) was applied by spraying and dipping methods to preserve papaya MJ9 during storage at room temperature.

The addition of lemongrass essential oil (1%) significantly inhibited the microbial growth on papaya MJ9 by reducing the value of total yeast and mold as compared to the control. Eeight loss, total soluble solid, vitamin C, and total titratable acid, papaya MJ9 with cassava starch-based edible coating incorporated with lemongrass essential oil (1%) had the lower values than control [38]. One study examined the effect of lemongrass oil *(Cymbopogon citratus),* citronella oil *(Cymbopogon winterianus)* and cajeput oil *(Melaleuca leucadendron)* against *Aspergillus niger* by the agar diffusion method. Alginate (1 % w/v) combines with lemongrass oil (5 µl /ml) maintained the antifungal effect after 14 days of preservation [39].

Sensory Score of Coated Mushroom during Preservation

Mechanical, barrier, and color properties of banana starch edible films incorporated with nanoemulsions of lemongrass (*Cymbopogon citratus*) and rosemary (*Rosmarinus officinalis*) essential oils was evaluated. Essential oils' nanoemulsions have a plasticizing effect increasing the film's water vapor permeability, transparency, and elongation at break, while the hydrophobic nature of the essential oils lead to a decrease in their water solubility [40]. The effect of essential oil (AE) lemongrass (Cymbopogon citratus) at concentrations of 0.05, 0.1 and 0.25% by physico-chemical, mechanical and barrier properties on chitosan films was investigated.

The results showed that films made with the essential oil of Cymbopogon citratus at concentrations of 0.1 and 0.25% Tween show a significant impact on the film thickness with respect to control and films with 0.05% AE [41]. In our experiment, sensory score of coated mushroom during preservation was presented in Table 4. It's clearly noted that formula N5 (2.0%: 2.5%: 2.0%) was appropriated for coating of mushroom.

Table 4: Sensory score of coated mushroom by different formula during preservation

Storage (day)	N1	N2	N3	N4	N5	N6	N7
0	$8.49±0.02^{a}$	$8.49±0.02^{a}$	$8.49±0.02^{a}$	$8.49±0.02^{a}$	$8.49±0.02^{a}$	$8.49±0.02^{a}$	$8.49±0.02^{a}$
1	$7.81±0.03^{d}$	$7.89±0.01^{cd}$	$8.03±0.03^{c}$	$8.12±0.01^{bc}$	$8.35±0.00^{a}$	$8.21±0.01^{b}$	$8.27±0.01^{ab}$
2	$7.72±0.01^{d}$	$7.81±0.02^{cd}$	$7.94±0.00^{c}$	$8.04±0.02^{bc}$	$8.31±0.03^{a}$	$8.16±0.00^{b}$	$8.20±0.03^{ab}$
3	$7.67±0.02^{d}$	$7.73±0.03^{cd}$	$7.87±0.00^{c}$	$7.95±0.03^{bc}$	$8.24±0.01^{a}$	$8.09±0.03^{b}$	$8.12±0.02^{ab}$
4	$7.58±0.00^{d}$	$7.65±0.02^{cd}$	$7.79±0.03^{c}$	$7.88±0.01^{bc}$	$8.19±0.02^{a}$	$8.01±0.01^{b}$	$8.05±0.00^{ab}$

5	7.49±0.00^{d}	7.57±0.01^{cd}	7.71±0.02^{c}	7.81±0.00^{bc}	8.13±0.00^{a}	7.93±0.01^{b}	8.00±0.01^{ab}
6	7.40±0.01^{d}	7.48±0.00^{cd}	7.63±0.02^{c}	7.74±0.02^{bc}	8.07±0.01^{a}	7.86±0.03^{b}	7.93±0.02^{ab}
7	7.31±0.03^{d}	7.40±0.03^{cd}	7.56±0.01^{c}	7.68±0.01^{bc}	8.01±0.02^{a}	7.80±0.02^{b}	7.85±0.00^{ab}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%)

Xanthan gum based edible coating plus cinnamic acid may contribute to reduce the surface browning and enhance the shelf-life of fresh-cut 'Nashpati' and 'Babughosha' for 4 days and 8 days, respectively at 4°C [20]. Flaxseed gum (FSG) in combination with lemongrass essential oil (LGEO) was investigated for coating of ready-to-eat pomegranate arils. Coatings containing LGEO were effective in reducing total plate count and yeast and mold populations. Increasing LGEO concentrations in the coatings resulted in more decline in microbial populations.

Reduced weight loss occurred in coated samples as compared to uncoated (control) sample. Coated samples showed a gradual decrease in ripening index in contrast with control where a significantly higher decline was observed. Total soluble solids, pH and titratable acidity significantly varied over the storage period. Color change (ΔE) for control increased steeply over the storage time in comparison to coated samples [42, 43]. The effect of chitosan (CH) (1%) along with guar gum (GG) (5, 15, and 25%) on the quality of shiitake mushroom (*Lentinus edodes*) stored at 4 ± 1 °C for 16 days was investigated. The results indicated that shiitake mushroom coated with CH 1% + GG 15% maintained higher tissue firmness, and slowed the rate of declines in soluble protein and ascorbic acid, as well as increases in total soluble solids, reducing sugar, malondialdehyde (MDA), and electrolyte leakage. Similarly, the effect of CH 1% + GG 15% coating in improving the overall quality of shiitake mushroom was identified through sensory evaluation.

Conclusion

Chitosan coating is beneficial to maintaining the storage quality and prolonging the shelf life of postharvest fruits and vegetables, which is always used as the carrier film for the antimicrobial agents. Appropriate coating can delay development of postharvest deterioration and senescence of this highly perishable commodity. In this research, we found that chitosan-lemongrass essential oil-xanthan gum coating would probably have wide prospect in the preservation of mushroom to extend its shelf-life during storage. From this approach, the added value of mushroom would be enhanced.

References

1. Mahajan PV, Rodrigues FAS, Motel A, Leonhard A (2008) Development of a moisture absorber for packaging of fresh mushrooms (Agaricus bisporous). Postharvest Biol. Technol., 48(3): 408-414.
2. Guillaume C, Schwab I, Gastaldi E, Gontard N Biobased packaging for improving preservation of fresh common mushrooms (Agaricus bisporus L.). Innov. Food Sci. Emerg., 11(4): 690-696.
3. Lopez-Briones GL, Varoguaux P, Chambroy Y, Bouquant J, Bureau G, Pascat B (1992) Storage of common mushroom under controlled atmospheres. International Journal of Food Science and Technology, 27: 493-505.
4. Roy S, Anantheswaran RC, Beelman RB (1995) Fresh mushroom quality as affected by modified atmosphere packaging. Journal of Food Science, 60(2): 334-340.
5. Ki Myong Kim, Jung A Ko, Jin Sil Lee, Hyun Jin Park, Miford A Hanna (2006) Effect of modified atmosphere packaging on the shelf-life of coated, whole and sliced mushrooms. LWT, 39: 364-371.
6. Zhaojun Ban, Li Li, Junfeng Guan, Jianhua Feng, Maoyu Wu, Xinming Xu, Jiang Li (2014) Modified atmosphere packaging (MAP) and coating for improving preservation of whole and sliced Agaricus bisporus. J. Food Sci. Technol., 51(12): 3894-3901.
7. Nguefack J, Dongmo JBL, Dakole CD, Leth V, Vismer HF, Torp J y, Nkengfack AE (2009) Food preservative potential of essential oils and fractions from Cymbopogon citratus, Ocimum gratissimum and Thymus vulgaris against

mycotoxigenic fungi. International Journal of Food Microbiology, 131(2-3): 151-156.

8. Hesham A Eissa (2007) Effect of chitosan coating on shelf life and quality of fresh-cut mushroom. Journal of Food Quality, 30(5): 623-645.
9. Tianjia Jiang, Lifang Feng, Xiaolin Zheng (2012) effect of chitosan coating enriched with thyme oil on postharvest quality and shelf life of shiitake mushroom (lentinus edodes). J. Agric. Food Chem., 60 (1): 188-196.
10. Youwei Y, Yinzhe R (2013) Effect of chitosan coating on preserving character of post-harvest fruit and vegetable: A review. J. Food Process Technol., 4: 254.
11. Jessica K. Alarcon-Moyano, Rube´n O. Bustos, Marıa Lidia Herrera, Silvia B Matiacevich (2017) Alginate edible films containing microencapsulated lemongrass oil or citral: effect of encapsulating agent and storage time on physical and antimicrobial properties. J Food Sci Technol., 54(9): 2878-2889.
12. Wannisornor B, Jarikasem S y, Soontorntanasart T (1996) Antifungal activity of lemon grass oil and lemon grass oil cream. Phytotherapy Research, 10(7): 551-554.
13. Parikh JK y, Desai MA (2011) Hydro distillation of essential oil from Cymbopogon flexuosus. International Journal of Food Engineering, 7(1): 1-8.
14. Burt S (2004) Essential oils: their antibacterial properties and potential applications in foods-A review. Int. J. Food Microbiol., 94: 223-253.
15. Bassolé IHN, Lamien-Meda A, Bayala B, Obame LC, Ilboudo a J, Franz Cy, Dicko MH (2011) Chemical composition and antimicrobial activity of Cymbopogon citratus and Cymbopogon giganteus essential oils alone and in combination. Phytomedicine: International Journal of Phytotherapy and Phytopharmacology, 18(12): 1070-1074.
16. Viuda-Martos, Ruiz-Navajas YM, Fernandez-Lopez J, Perez-Alvarez J (2008) Antifungal activity of lemon (Citrus lemon L.), mandarin (Citrus reticulata L.), grape fruit
(Citrus paradisi L.) and orange (Citrus sinensis L.) essential oils. Food Control, 19: 1130-1138
17. Sanchez-Garcia C, Cruz-martin M, Alvaradocapó Y, Pérez M y, Medinilla M (2007) para el control de microorganisms contaminantes del cultivo in vitro de plantas. Biotecnología Vegetal., 7(3): 187-190.
18. Sanchez-Gonzaez, Laura, Marıa Vargas, Chelo Gonzalez-Martinez, Amparo Chiralt, Maite Chafer (2011) Use of essential oils in bioactive edible coatings: A review. Food Engineering Reviews, 3: 1-16.
19. Ojagh SM, Rezaei M, Razavi SH y, Hosseini SMH (2010) Effect of chitosan coatings enriched with cinnamon oil on the quality of refrigerated rainbow trout. Food chemistry, 120(1): 193-198.
20. Sonu Sharma, TV Ramana Rao (2015) Xanthan gum based edible coating enriched with cinnamic acid prevents browning and extends the shelf-life of fresh-cut pears. LWT - Food Science and Technology, 62: 791-800.
21. Mohamed AYI, Aboul-Anean HE, Hassan AM (2013) Utilization of edible coating in extending the shelf life of minimally processed prickly pear. Journal of Applied Sciences Research 9: 1202-1208.
22. Freitas IR, Cortez-Vega WR, Pizato S, Prentice-Hernandez C, Borges CD (2013) Xanthan gum as a carrier of preservative agents and calcium chloride applied on fresh-cut apple. Journal of Food Safety, 33: 229-238.
23. Zambrano-Zaragoza ML, Mercado-Silva E, Del Real LA, Gutierrez-Cortez E, Cornejo-Villegas MA, Quintanar-Guerrero D (2014) The effect of nanocoatings with a-tocopherol and xanthan gum on shelf-life and browning index of fresh-cut "Red Delicious" apples. Innovative Food Science and Emerging Technologies, 22: 188-196.
24. Qihui Huang, Xiaochen Qian, Tianjia Jiang, Xiaolin Zheng (2019) Effect of chitosan and guar gum based composite edible coating on quality of mushroom (Lentinus edodes) during postharvest storage. Scientia Horticulturae, 253(27): 382-389.
25. Velickova E, Winkelhausen E, Kuzmanova S, Alves VD, Moldão-Martins M (2013) Impact of chitosan-beeswax edible

coatings on the quality of fresh strawberries (Fragaria ananassa cv Camarosa) under commercial storage conditions. Food Sci. Technol-LEB, 52: 80-92.

26. Zhong QP, Xia WS (2007) Effect of 1-methylcyclopropene and/or chitosan coating treatments on storage life and quality maintenance of Indian jujube fruit. Food Sci. Technol-LEB, 40: 404-411.
27. Gao P, Zhu Z, Zhang P (2013) Effects of chitosan-glucose complex coating on postharvest quality and shelf life of table grapes. Carbohyd. Polym., 95: 371-378.
28. Perdones A, Sánchez-González L, Chiralt A, Vargas M (2012) Effect of chitosan-lemon essential oil coatings on storage-keeping quality of strawberry. Postharvest Biol. Tec., 70: 32-41.
29. Ibrahim MA, Sharoba AM, El Waseif KH, El Mansy HA, El Tanahy HH (2017) Effect of edible coating by chitosan with lemongrass and thyme oils on strawberry quality and shelf life during storage. Journal of Food Technology and Nutritional Sciences, 3(1): 1-11.
30. Antunes MDC, Dandlen S, Cavaco AM, Miguel G (2010) Effects of postharvest application of 1-MCP and postcutting dip treatment on the quality and nutritional properties of fresh-cut kiwifruit. J. Agric. Food Chem., 58: 6173-6181.
31. Qi HP, Hu W, Jiang A, Tian M, Li Y (2011) Extending shelf-life of Fresh-cut 'Fuji' apples with chitosan-coatings. Innovative Food Science and Emerging Technologies, 12: 62-66.
32. Xiao Z, Luo Y, Luo YG, Wang Q (2011) Combined effects of sodium chlorite dip treatment and chitosan coatings on the quality of fresh-cut d Anjou pears. Postharvest Biol. Tec., 62: 319-326.
33. Mafune Mpho, Dharini Sivakumar, Periyar Selvam Sellamuthu and Silvia Bautista-Baños (2013) Use of lemongrass oil and modified atmosphere packaging on control of anthracnose and quality maintenance in avocado cultivars. Journal of Food Quality, 36: 198-208.
34. Akbudak N, Tezcan H, Akbudak B, Seniz V (2006) The effect of harpin protein on plant growth parameters, leaf chlorophyll, leaf colour and percentage rotten fruit of pepper plants inoculated with Botrytis cinerea. Sci. Hortic-Amsterdam, 109: 107-112.
35. Jiang T, Feng L, Li J (2012) Changes in microbial and postharvest quality of shiitake mushroom (Lentinus edodes) treated with chitosan-glucose complex coating under cold storage. Food Chem., 131: 780-786.
36. Wang SY, Gao H (2013) Effect of chitosan-based edible coating on antioxidants, antioxidant enzyme system, and postharvest fruit quality of strawberries (Fragaria x aranassa Duch.). Food Sci. Technol-LEB, 52: 71-79.
37. Nima Azarakhsh, Azizah Osman, Hasanah Mohd Ghazali, Chin Ping Tan, Noranizan Mohd Adzahan (2014) Lemongrass essential oil incorporated into alginate-based edible coating for shelf-life extension and quality retention of fresh-cut pineapple. Postharvest Biology and Technology, 88: 1-7.
38. D Praseptiangga, R Utami, L U Khasanah, I P Evirananda, and Kawiji (2017) Effect of cassava starch-based edible coating incorporated with lemongrass essential oil on the quality of papaya MJ9. International Conference on Advanced Materials for Better Future, IOP Conf. Series: Materials Science and Engineering, 176: 012-054.
39. My Dong Lieu, Nguyen Nhat Ha Ngo, Thuy Linh Lieu, Kim Thach Nguyen, Thi Kim Thuy Dang (2018) The efficacy of combined application of edible coatings and essential oil in mango preservation. Vietnam Journal of Science and Technology, 56(4): 458-467.
40. Andrea E Restrepo, José D Rojas, Omar R García (2018) Mechanical, barrier, and color properties of banana starch edible films incorporated with nanoemulsions of lemongrass (Cymbopogon citratus) and rosemary (Rosmarinus officinalis) essential oils. Food Science and Technology International, 24(8): 705-712.
41. Vázquez-M, Guerrero-J, Mata-M (2014) Effect of essential oil of cymbopogon citratus on physico-chemical properties, mechanical and barrier films of chitosan. Ecorfan-Bolivia Journal, 1(1): 12-20.
42. Basharat Yousuf, Abhaya Kumar Srivastava (2017) Flaxseed gum in

combination with lemongrass essential oil as an effective edible coating for ready-to-eat pomegranate arils. International Journal of Biological Macromolecules, 104: 1030-1038.

43. Nussinovitch A, Kampf N (1993) Shelf life extension and conserved texture of alginate coated mushrooms (Agaricus bisporus). Journal of Food Technology, 26: 469-475.

