EFFECT OF ARABIC GUM-CARBOXYMETHYLCELLULOSE EDIBLE COATINGS ON SHELF LIFE OF BUTTON MUSHROOM *(Agaricus bisporus)*

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Abstract

Arabic gum (GA) and Carboxymethylcellulose (CMC) based formulations have been evaluated as protective edible coatings. Button Mushrooms were coated by dipping in aqueous mixtures of 1% GA and 1% plasticizer (glycerol) for CMC additions of 1 and 2% wt. Mushrooms were stored at refrigerated temperature (4±1ºC, 92±2 % RH), and loss of weight (%), color of cap portion (Lab value), firmness (Newton), protein content (g/100g), ash content (%), moisture content (%), TPC (log CFU/g), TYMC (log CFU/g) were assessed. Both coatings resulted in a reduction of weight loss, preserving firmness and delaying skin color changes. Mushroom coated with coating A was seen maintaining tissue firmness and showed reduction in microbial counts compared with the control. In addition, gum arabic associated with carboxymethylcellulose coating also delayed enzymatic browning and maintained the color of cap portion. The shelf life of mushroom was better for 1% GA + 2% CMC treatment. This study suggests that by using 1% CMC with gum arabic as an edible coating, the decaying of Button Mushroom can be delayed and the color and firmness can be preserved for up to 12 days during storage at 4±1º C.

Keywords: *Agaricus bisporus, Gum Arabic, Carboxymethylcellulose, Glycerol, Physico-chemical Analysis, Microbiological Analysis, Shelf life.*

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1. INTRODUCTION

Mushrooms is used not only as food, but also as functional food and medicines due to their high amount of proteins and minerals, low starch and cholesterol contents and presence of various bioactive compounds (Wani et al., 2010). Button Mushrooms are considered to be the protein food products of the future. From the point of view of post-harvest physiology, mushroom is one of the most sensitive agricultural crops after harvesting, because there is no cuticle on the cap surface to protect it from physical damage, water evaporation and microbial attack The annual world production of Button Mushroom has reached 6.5 million tonnes and that of all types of mushrooms is estimated to be over 27 million tonnes. India has registered twenty-fold increase in production of mushrooms in the last four decades and our production is 1.2 lakh tonnes. Button Mushroom continues to occupy a prominent place and contributes about 80-85% of the total mushroom production of our country (DMR-ICAR, 2015).

The shelf life of Button Mushroom is limited to a couple of days, due to enzymatic browning. Application of semi-permeable coatings has been shown to improve the storage life of fruit and vegetables. The semipermeable barrier provided by edible coatings is aimed to extend shelf life by reducing moisture and solute migration, gas exchange, respiration, and oxidative reaction rates, as well as suppress physiological disorders on fresh-cut fruits (Rojas-Graü *et al*., 2007)

Gum arabic is a dried, gummy exudate from the stems or branches of Acacia species. It is the least viscous and most soluble of the hydrocolloids, and is used extensively in the industrial sector because of its emulsification, film-forming and encapsulation properties. Chemically, Gum Arabic (GA) is a complex mixture of macromolecules of different size and composition (mainly carbohydrates and proteins). Today, the properties and features of GA have been widely explored and developed in food industry, it is used as a stabilizer, a thickener and/or an emulsifier agent (e.g., soft drink syrup, gummy candies and creams) (Verbeken *et al.*, 2003). It is water soluble and can be transformed into transparent and resistant films by small additions of plasticizers and Carboxymethylcellulose (CMC).

Carboxymethyl cellulose (CMC) is a linear, long-chain, water-soluble, anionic polysaccharide that can be used as fruit coating. Purified CMC is a white to cream-colored, tasteless, odourless, free-flowing powder. Edible coatings can also serve as carriers of food additives, e.g. antibrowning and antimicrobials agents, colorants, flavors, nutrients, and spices (Pranoto *et al*., 2005).

However, to the best of our knowledge, the use of gum arabic in combination with carboxymethylcellulose has not been studied to date, on fresh Button Mushroom. Thus, the objectives of this study were: (**1)** To study the effect of Arabic Gum - carboxymethylcellulose edible coating on Physico-chemical properties of Button Mushroom (*Agaricus*

bisporus). **(2)** To study the effect of Arabic gum-carboxymethylcellulose edible coating on shelf life of Button Mushroom (*Agaricus bisporus*) at low temperature (4°C±1).

2. MATERIAL AND METHODS

2.1 Raw Material

Fresh Button Mushrooms were procured from local wholesaler in Allahabad. Bright colored firm mushrooms, free from blemishes, apparent disease, and mechanical damage, were first selected. The crop was immediately pre-cooled for 2 h in refrigerator before the start of experiment.

2.2 Coating Preparation

Arabic gum **(Make: Merck Specialties)** and CMC was used for coating preparation. The coating formulations was prepared by dissolution of GA (1% w/w) in distilled water on hot plate by continuous stirring at 40ºC for 20 min. After complete solubilization, carboxymethylcellulose (CMC) was separately added in two concentrations: 1 and 2% (w/v). Subsequently 1% (v/v) of glycerol **(Gly— Make: Fischer Scientific)** was added to the solution. It act as a plasticizer which was stirred continuously with magnetic bar for 20 min. to assure homogenization. The pH of the solutions was 5.6. The coatings was allowed to cool at 20ºC. For identification coating A refers to the composition made of 1% GA; 1% CMC; 1% Gly and coating B refers that of 1% GA; 2% CMC; 1% Gly.

2.2. Coating of Button Mushroom

Button Mushroom free from physical damage were sorted into similar size and mass. Firstly, slicing of mushroom was done in 1 cm size using sanitized sharp knife. Then mushroom were immersed in distilled water for 1 min and excess water was dried at room temperature using muslin cloth. After that the samples were dipped into both coatings for approximately 2 min and the excess gel were drained away. The coatings were dried at room temperature keeping the samples in muslin cloth. The uncoated samples were taken as control. The samples (coated and uncoated) were packed separately in LDPE and heat sealed and stored at low temperature (4±1ºC) and RH= 92±2%).The samples were analysed before treatment (day 0) and at 4 day intervals up to 12 days. 16 packets, 100g each were taken for both the coatings and 16 other samples remained uncoated as control samples.

2.3 Physico-Chemical Analytical Method

2.3.1 Physiological Loss in Weight (%)

For determining the loss in weight**,** mushrooms were weighed after imposing the treatment which served as the initial weight. The loss in weight was recorded at each regular interval until the product was spoiled, which served as the final weight. The PLW was determined by the following formula and expressed as percentage.

$$\text{Weight loss } (\%) = \left(\frac{A-B}{A}\right) * 100 \quad \ldots\ldots\ldots (1)$$

Where, A – Original mushroom weight (g)
B – Final mushroom weight (g)

2.3.2 Moisture Content (%) (By AOAC)

The moisture content of the sample was determined by using hot air oven drying method. Weigh 5-6 gm powder in an aluminium dish using an electronic weighing machine. Then the aluminium dish was kept in the hot air oven for 2 hrs at 105°C. After this, remove it from hot air oven and cooled in a desiccators and then weighed again. Loss of weight in percentage was moisture content. The moisture content of the sample was computed using the following equation.

$$\text{Moisture content } (\%) = \frac{W1-W2}{W1-W} \times 100 \ldots (2)$$

Where,
W_1 = weight of the dish with the material before drying in g.
W_2 = weight of the dish with material after drying in g.
W = weight of the empty dish in g

2.3.3 Ash Content by Muffle Furnace (By Ranganna, 1986)

The powdered mushroom sample (5.0 g) was ashed in a Muffle furnace in previously ignited and cooled crucible of known weight at 550°C for 6 h. Fairly cooled crucibles were put in desiccators and weighed.

$$\text{Ash } \% = \frac{W_2-W_1}{W} * 100 \quad \ldots\ldots (3)$$

Where,
W_2 = Final weight of (dish + Ash) in g
W_1 = Weight of dish in g
W = Weight of sample in g

2.3.4 Color Measurement

The color change was observed by colorimeter using X rite Color Lab Method. Color is a three dimensional characteristics of appearance consisting of a lightness attributes, often called "Value", and two chromatic attributes, called "Hue" and "Chroma". The Hunter colour scale is represented by "*L*" (0 = perfect black, 100 = perfect white), "*a*" (-*a* = greenness, "+*a*" = redness) and "*b*" ("-*b*" = blueness, "+*b*" = yellowness). (Brimelow and Joshi, 2001).

2.3.5 Protein Content

Five grams of dried and grinded mushroom samples were dissolved in 50 ml of 0.1N NaOH and boiled for 30 minutes. After cooling and centrifuging at 1000 rpm the supernatant was collected and total protein content was determined by **Lowry**, Roseborough, Farr & Randall, 1951 (Sadasivam A.Manikam ,Biochemical method for agricultural sciences).

2.3.6 Firmness Measurement

Firmness of mushroom was measured by texture analyser. The instrument had a micro-processor regulated texture analysis system interfaced to a personal computer. The instrument consists of two separate modules; the test-bed and the control console (keyboard). Both are linked by a cable which route low voltage signal and power through it. The texture analyzer measured force, distance and time and hence provided a three-dimensional product analysis. Forces may be measured to achieve set distances and distances may be measured to achieve set forces.

2.3.7 Microbiological Analysis

Microbial analysis was to determine the total plate count & yeast and mould count of the samples on Nutrient Agar medium for bacterial count and Potato Dextrose Agar medium for yeast and mold count.

Twenty-five gram mushrooms were removed aseptically from each pack and diluted with 225 ml 0.1% peptone water. The sample was homogenised for complete mixing. Seven sterilized test tubes were taken and numbered, each containing 9ml Ringer solution. These were closed with cotton plugs and then sterilized in autoclave. 1ml of the sample mixed in test tube containing 9 ml of ringer solution to make 10^{-3} dilution.

2.3.7.1. Standard Plate Count

Procedure: Cleaning, sterilization, preparation of media, pouring of plates. Standard plate Count (SPC) procedure was used to determine the number of microorganisms in the sample. It is an agar plate method for estimating population of bacteria. 1ml of each dilution was transferred to sterilized Petri plate, 10ml of the sterilized melted cooled agar medium was added to each plate and each plate was rotated gently, immediately after addition of the medium for uniform distribution of the organisms and the agar was allowed to solidify. Then the plates were placed into the incubator for 48hrs and then the former colonies were counted on the plates.

CFU/ml = number of colonies per ml plated /Total dilution factor ….. (4)

2.3.7.2. Yeast and Mold Count

Procedure: Sterilized Petri dishes were taken to the laminar air flow cabinet and ultra violet light was switched on for 30minutes. After then UV light was switched off. Pipette 1 ml of sample of dilution which has been selected for plating into a petri dish in duplicate. Pour 10-12 ml of the Potato dextrose agar medium & allowed to solidify. Then the plates were placed into the incubator for 48hrs and then the former colonies were counted on the plates and no. of colonies per ml was counted by formula as described in eq. IV.

2.3. Statistical Analysis

The experiment was conducted by adopting completely randomized design the data recorded during the course of investigation were statistically analyzed by the 'Analysis of variance- One way classification or single factor 'ANOVA'(Fisher 2000). It gives an appropriate method capable of analyzing the variation of population variance. The significant effect of treatment was judged with the help of 'F' (variance ratio). Calculated F value was compared with the table value of F at 5% level of significance. If calculated value exceeded the table value the affect was considered to the significant. The significance of the study was tested at 5% level. Relationships with the storage time were established by a linear regression model along with the R^2 value.

3. RESULTS AND DISCUSSION

After solvent evaporation (10 min in air at room temperature) both formulations resulted in a highly transparent coating invisible to the naked eye.

3.1 Effect of GA and CMC on Weight Loss (%) of Button Mushroom during Storage.

Weight loss as a result of desiccation is a problem for the mushroom postharvest quality during storage. Fig. 1 shows the reduction in weight loss for both coated and uncoated mushrooms. Button Mushroom coated with edible coatings showed significantly lower weight loss as compared to the control at low temperature (4±1°C). Although percentage weight loss increased during the storage period from 0 day to 12^{th} day in case of control stored samples because of low temperature while the rate of percent weight loss was much slower in coated sample. Coating A shows less weight loss as compared to coating B. The protective effect is observed after day 4 when the values become statistically significant at 5%.

Minimum weight loss in treatment Coating A might be due to edible coating, which acts as a barrier between inner and outer environment that reduces respiration rate. Hence, it retained weight in vegetable throughout the storage period. This data can be approximated to a linear model, such as (y = mx+c) which facilitates its interpretation. Such fitting gives m: the curve inclination (slope) that is physically interpreted as the rate of mass loss. In other words, the higher m the greater will be the dehydration as a function of time.

3.2 Effect of GA and CMC on Moisture Content (%) of Button Mushroom during Storage.

Mushrooms respire after harvest therefore their moisture content reduces during storage. Maximum moisture content of 88.37% was recorded in Coating A while the lowest was observed in control having 83.98% of the total water present in mushroom. Coating B also showed reduction in moisture loss but at different rate.

Post-harvest edible coating application reduced moisture loss of mushrooms to a great extent as compared to the normal

uncoated control mushroom after harvest. However studies shows that when the samples were stored at low temperature, there found no significant variations in the initial and 8th day of moisture content of coated mushroom samples because of low rate of evaporation but there is variation in moisture content at the 12th day of storage of mushroom (Fig. 2).

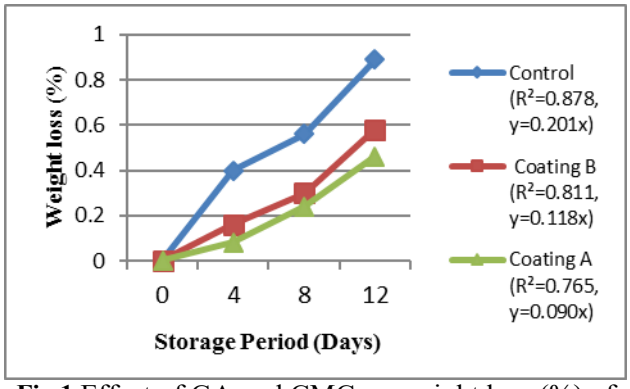

Fig.1 Effect of GA and CMC on weight loss (%) of Button Mushroom during storage.

Loss in moisture content may be due to that mushroom is not protected by an external epidermal structure, thus the transpiration rate from the fruiting body is very high and **(San Antonio and Flegg, 1964)**. Thus layer formed through coatings on the surface of mushroom act as a barrier that protect the water loss.

3.3 Effect of GA and CMC on Ash Content (%) of Button Mushroom during Storage.

There were very less variations on the percentage of

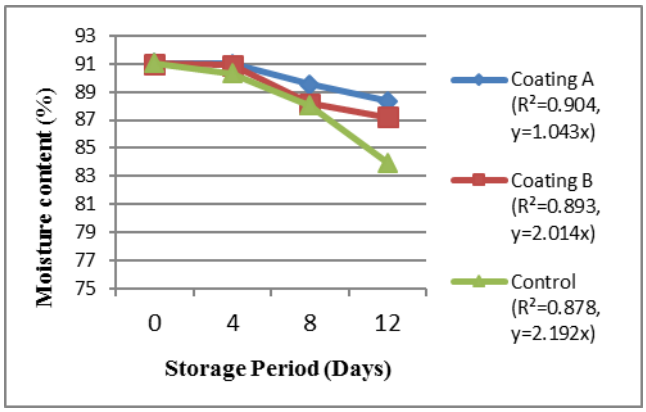

Fig 2. Effect of GA and CMC on moisture content (%) of Button Mushroom during storage

samples during storage on coated and uncoated mushrooms. Because the ash content only gives an idea about non-volatile material present in food and undergoes very minimum change and does not disintegrate during storage period. **Khaliq *et al.*, (2015)** obtained similar result for mango coated with gum arabic and CaCl2 during storage at 6ºC.

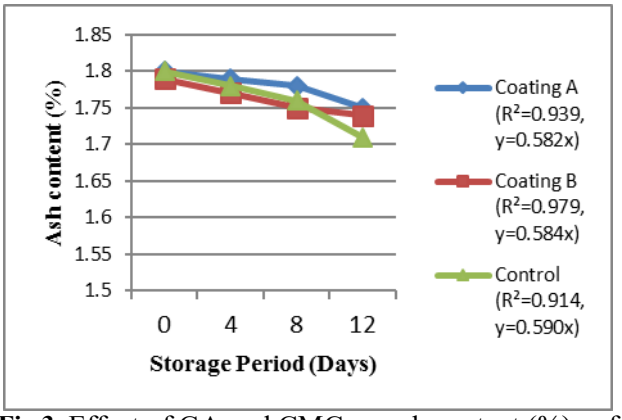

Fig 3. Effect of GA and CMC on ash content (%) of Button Mushroom during storage.

3.4 Effect of GA and CMC on Protein content (gm/100gm) of Button Mushroom during Storage.

Edible mushrooms are highly valued as a good source of protein. Protein content of mushroom reduces during storage due to higher activity of enzymes. On the critical evaluation of the result, it was found that the protein content of mushroom packed in LDPE decreased with increase in storage period. Here, Coating B has more significant result than coating A. The rate of protein reduction decreases on applying coating**. (Crisan and Sands 1978)** observed that mushroom in general contains 90% water and 10 % dry matter that include 3.7g protein content in *Agaricus bisporus*. Reduction in protein content might be due to protease activity that increased free amino acid. **Jiang *et al.*, (2012)** obtained similar result for shitake mushrooms coated with gum arabic enriched with natamycin.

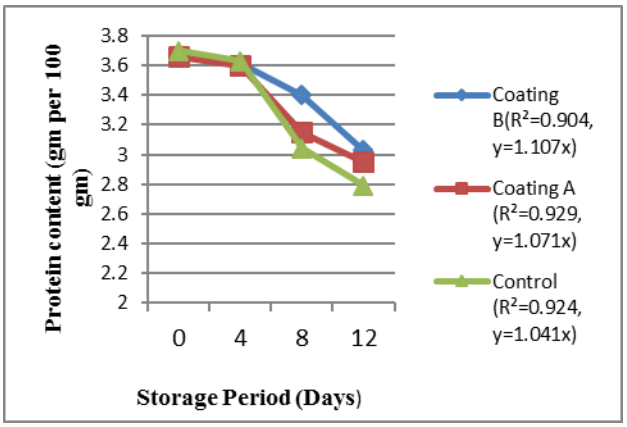

Fig.4 Effect of GA and CMC on Protein content (gm/100gm) of button mushroom during storage

3.5 Effect of GA and CMC on Firmness of Button Mushroom during Storage.

Loss of texture is one of the main factors limiting quality and the postharvest shelf-life of fruit and vegetables. Initial firmness values were similar for control and treated samples. However, control mushrooms had the fastest softening rate, losing about 20% of their firmness in about 12 d. The firmness of coating A mushroom also decreased but to a

lesser extent, 13.3% lower than that of the control in 12 d. CMC at 1% treatment led to a significantly higher firmness than that in the coating B samples, due to a synergistic effect of GA and CMC at 1%. Coating B result was not significant which shows that CMC at 2% with GA leads to loss in firmness by softening the tissue.

Loss In firmness is due to degradation of cell wall by bacterial enzymes. This kind of softening was observed in control samples but was inhibited by Coating A treatment due to its higher antifungal activity and covering. Ali *et al.,* (2010) obtained similar result for tomato treated with 20% Gum Arabic during storage.

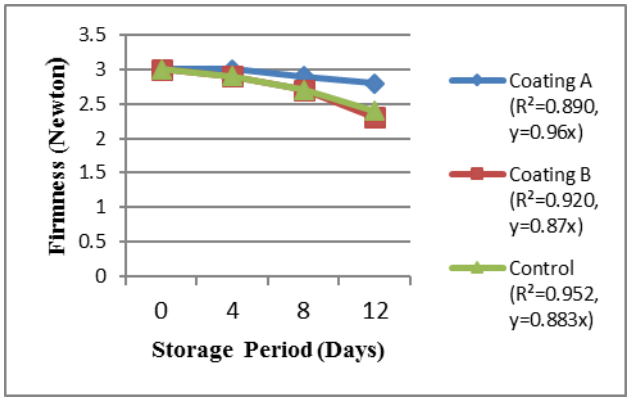

Fig. 5 Effect of GA and CMC on firmness of Button Mushroom during storage.

3.6 Effect of GA and CMC on Color and Appearance of Button Mushroom during Storage.

The mushroom color changed as a result of storage, and both a* and b* values were increased, but L value reduced rapidly with the storage period for untreated mushrooms. The Lightness of the untreated mushrooms reduced from 88.68 to 67.34 which were not in acceptable limit. The effect of Coating A was more effective than Coating B and L value recorded for Coating A and Coating B were 72.57 and 70.36 at the 12th day of storage. The graphical representation shows that there was not much difference between the coated and uncoated mushroom till 4th day of storage but after 8th day Coating A gave significant result and maintain the lightness of the cap portion of mushroom.

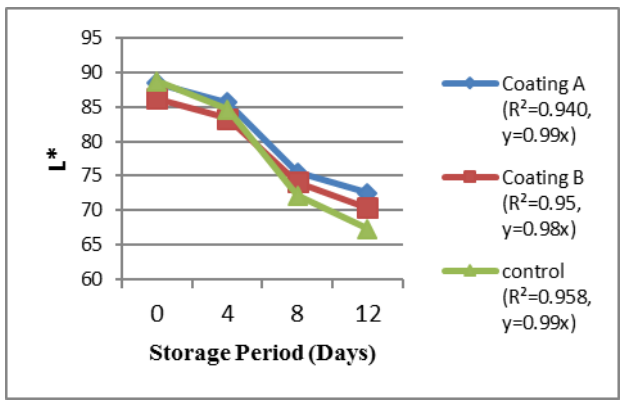

Fig. 6.1 Effect of GA and CMC on L* Value of Button Mushroom during storage.

The increasing value of a* and b* shows the redness and yellowness of the mushrooms respectively. The greater a* value corresponded to the increasing enzymatic browning during storage. Coating A showed the significant result. Between both the treatment, color was best retained in Coating A and the maximum browning was observed in control sample (Fig. 6.2 and 6.3).

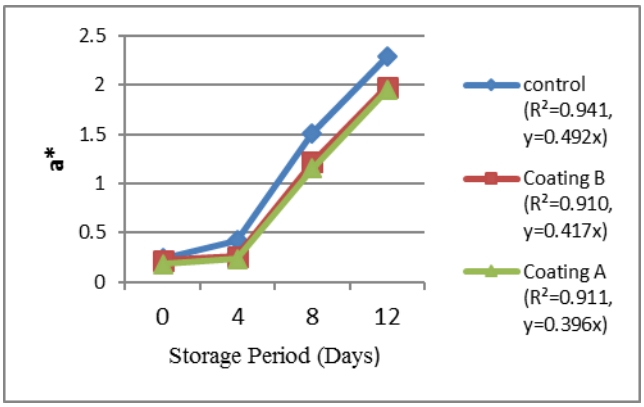

Fig. 6.2 Effect of GA and CMC on a* Value of Button Mushroom during storage.

Enzymatic browning catalysed by enzyme tyrosinase is responsible for change in color of mushroom. Similar results were obtained by Azam Niazmand *et al*., 2009 where mushrooms coated with three edible polysaccharide coatings including High Methoxy Pectin (HMP), Commercial starch (%3) and Carboxy Methyl Cellulose(%0.17) were investigated on the shelf life of mushroom.

3.7 Effect of GA and CMC on Total Plate Count of Button Mushrooms during Storage.

The results showed that the counts reached to 3.76 log CFU/g for coating A and 3.95 log CFU/g for coating B after 12 days of storage, as compared with the initial counts 2.66 log CFU/g and 2.67 of coating A and B respectively. Uncoated treatment indicates higher counts than the coated one with 5.24 log CFU/g after12 day of storage which is not under acceptable limit. The coating containing 1% CMC and Arabic gum reduced the viable count by 2 logs CFU/g. Fig 7 shows the growth rate of microbial count for coated and uncoated mushroom.

It can be noticed that Coating A has remarkable effect on the rate of microbial counts during storage at cold temperature. The addition of Arabic gum decreased the microbial counts by reducing the fermentation prosecco. Lee *et al*., 2004 stated that the coating treatment of fruits and vegetables allowed a limited gases exchange and respiration, moreover, prevented the occurrence of fermentation process and minimized the microbial count.

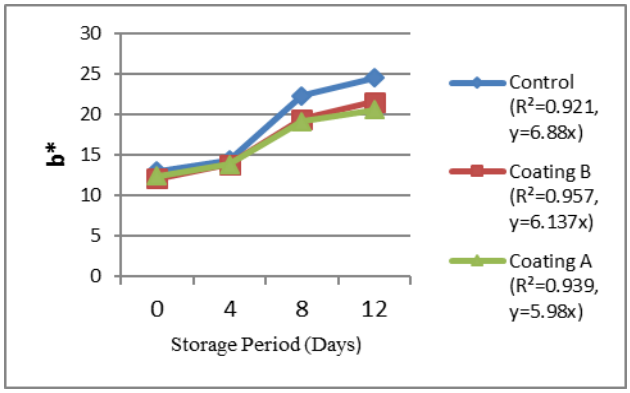

Fig. 6.3 Effect of GA and CMC on b* Value of Button Mushroom during storage.

3.8 Effect of GA and CMC on Total Yeast and Mold Count of Button Mushrooms during Storage.

The results indicate that the counts gradually increased with increasing the storage period at low temperature in both samples packaged in uncoated and uncoated forms. The counts reached to 3.15 log CFU/g for coating A and 3.93 log CFU/g for coating B after 12 days of storage, as compared with the initial counts 1.35 log CFU/g and 1.38 of coating A and B respectively. Uncoated mushroom indicates higher counts than the coated one with 4.57 log CFU/g at 12th day which is not under acceptable limit.

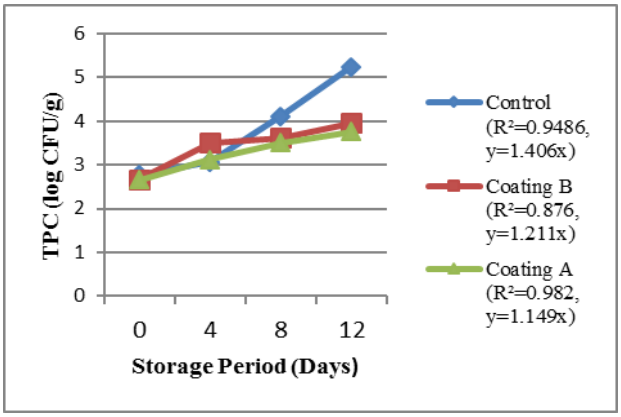

Fig. 7 Effect of GA and CMC on Total Plate Count of Button Mushrooms during storage.

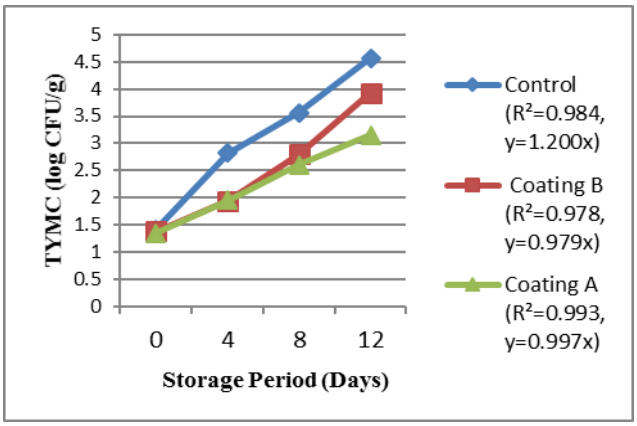

Fig.8 Effect of GA and CMC on Total Yeast and Mold Count of Button Mushrooms during storage.

Coating of fresh mushrooms with Arabic gum (1%) plus CMC (1%) has remarkable effect on the rate of microbial counts during storage at cold temperature.

4. CONCLUSION

After the completion of the work we had ended with a cheaper alternative in comparison to other edible coating by mixing Arabic Gum, Carboxymethylcellulose and Glycerol. The coating could increase the shelf life of Button Mushroom, the rich source of protein and carbohydrate as the shelf life of mushroom is a 2-3 days only at ambient temperature. So many attempts was made to increase the shelf life of Button Mushroom by applying edible coating, antimicrobial wash, modified atmosphere packaging, humidity controlled packaging and irradiation.

The use of Arabic gum associated with Carboxymethylcellulose as edible coating on mushrooms packed in LDPE at refrigeration temperature could reduce the metabolic activity respiration rate and thereby extends the shelf life of Button Mushrooms from 6 to 12 days. The observations of various quality parameters (physio-chemical and microbiological) during the study also support this result.

The application of coating mainly reduced weight loss, enzymatic browning and microbial contamination and maintained its color, appearance, firmness and nutritional value during storage. This implies that the 1% GA associated with 1% CMC and 1% glycerol coating was effective in increasing the shelf life of Button Mushroom.

Earlier Arabic gum with other chemicals was used to increase the shelf life of Button Mushroom but the incorporation of Carboxymethylcellulose reduced the use of Gum Arabic to 1% only which is a major achievement. Samples were coated by dipping in aqueous mixtures of 1% GA and 1% plasticizer (glycerol) for CMC additions of 1% and 2%.

At the end it can be concluded that Gum Arabic and CMC coatings is inexpensive technology that can extend the shelf life of fresh Button Mushroom when packed in LDPE and stored at refrigerated temperature.

Fig. 9 Effect of storage on appearance of control Button Mushroom.

Fig. 10 Effect of Coating A on appearance of Button Mushroom during storage.

Fig. 11 Effect of Coating B on appearance of Button Mushroom during storage.

REFERENCES

[1] **A.O.A.C. (2000)**. Association of Official Analytical Chemists. Washington DC. International 17th Edition, Revision I.

[2] **Ali A, Maqbool M, Ramachandran S and Alderson P G (2010)**. Gum arabic as a novel edible coating for enhancing shelf-life and improving postharvest quality of tomato (*Solanum lycopersicum L.*) fruit. Postharvest Biology and Technology. 58: 42– 47.

[3] **Brimelow and Joshi (2002).** Colour measurement of foods by colour reflectance. Chapt. 5 in "Colour in Food; Improving Qualiyu", ed. D.B. Mac Dougall,. CRC Press, Boca Raton, Fla. pp. 82-114.

[4] **Burton K (1989)**. The quality and storage life of *Agaricus bisporus.* Mushroom Science xii (part 1) In: Proceedings of the twelfth International Congress on the science and cultivation of edible fungi, Braunschweig, Germany. pp. 287-293.

[5] **Crisan EW and Sands (1978)**. A Nutritional value, Biology and cultivation of edible mushrooms, Academic press 172-189.

[6] **Dr. S. Ayyappan (2015*).*** Directorate of Mushroom Research**.** Indian Council of Agricultural Research. www.nrcmushroom.org. Chambaghat, Solan (HP) 173-213.

[7] **Jiang, Wang and Ying (2010).** Structure and composition changes in the cell wall in relation to texture of shiitake mushrooms (Lentinula edodes) stored in modified atmosphere packaging. *Journal of the Science of Food and Agriculture,* 90: 742–749.

[8] **Khaliq *et al*., (2015)**. Influence of gum arabic enriched with calcium chloride on physiological, biochemical

and quality responses of mango (Mangifera indica L.) fruit stored under low temperature. *Postharvest Biology and Technology*. 362-369.

[9] **Lee, JY, Park HJ, Lee CY, Choi WY (2003).** Extending shelf-life of minimally processed apples with edible coatings and antibrowning agents. *Lebensmittel-Wissenschaft und Technologie,* 36-3, 323-329.

[10] **Pranoto Y, Salokhe VM, Rakshit SK (2005).** Physical and antibacterial properties of alginate-based edible film incorporated with garlic oil. *Food Research International* 38: 267–72.

[11] **Rojas-Graü MA, Tapia MS, Rodríguez FJ, Carmona AJ, Martin-Belloso O (2008),** Using polysaccharide-based edible coatings to maintain quality of fresh-cut Fuji apples. *LWT - Food Science and Technology*, 41-1, 139-147.

[12] **Rojas-Grau, MA Oms-Oliu G, Soliva Fortuny, R and Martın Belloso O (2009)**. The use of packaging techniques to maintain freshness in fresh-cut fruits and vegetables: a review. *International Journal of Food Science and Technology*. 44: 875-889.

[13] **San Antonio JP and Flegg PB (1964)**. Transpiration from Sporophore of *Agaricus bisporus* White. American Journal of Botany 51(10):1129.

[14] **Verbeken, D Dierckx S. and Dewettinck (2003)**. Exudate gums: Occurrence, production,and applications. Applied Microbiology and Biotechnology. 63 (1):10–21.

[15] **Wani BA, Bodha RH, Wani AH (2010).** Nutritional and medicinal importance of mushrooms. J. Med. Plants 4(24): 2598-2604.

[16] **Xie-Jiannhua, Pany-Jin and PangJie (2003).** Keeping effect of litchi coated with edible konjac glucomanan. Food and Machinary, 3: 20-21.

APPENDIX A

Table 1 Effect of GA and CMC on weight loss (%) of Button Mushroom during storage

Samples	Storage (Day)			
	0	**4**	**8**	**12**
C	0	0.40	0.56	0.89
A	0	0.08	0.24	0.46
B	0	0.16	0.30	0.58
F- test	S			
S. Ed. (±)	0.060			
. D. (P = 0.05)	0.127			

Table 2. Effect of GA and CMC on moisture content (%) of Button Mushroom during storage.

Samples	Storage (Days)			
	0	**4**	**8**	**12**
C	91.05	90.33	88.02	83.98
A	91.03	90.98	89.53	88.37
B	91.02	90.93	88.15	87.21
F- test	NS			
S. Ed. (±)	0.606			
. D. (P = 0.05)	1.285			

Table 3. Effect of GA and CMC on ash content (%) of Button Mushroom during storage.

Samples	Storage (Days)			
	0	**4**	**8**	**12**
C	1.80	1.78	1.76	1.71

A	1.80	1.79	1.78	1.75
B	1.79	1.77	1.75	1.74
F- test	S			
S. Ed. (±)	0.036			
C. D. (P = 0.05)	0.076			

Table 4. Effect of GA and CMC on Protein content (gm/100gm) of Button Mushroom during storage.

Samples	**Storage (Days)**			
	0	**4**	**8**	**12**
C	3.70	3.63	3.04	2.79
A	3.66	3.60	3.15	2.95
B	3.67	3.61	3.40	3.03
F- test	NS			
S. Ed. (±)	0.058			
C. D. (P = 0.05)	0.123			

Table 5. Effect of GA and CMC on color and appearance of Button Mushroom during storage.

Days	**Control**			**Coating A**			**Coating B**		
	L*	**a***	**b***	**L***	**a***	**b***	**L***	**a***	**b***
0	88.68	+0.24	+13.00	88.47	+0.18	+12.34	86.18	+0.22	+12.06
4	84.59	+0.42	+14.37	85.65	+0.23	+13.79	83.29	+0.26	+13.84
8	72.20	+1.51	+22.28	75.50	+1.15	+19.08	74.15	+1.22	+19.39
12	67.34	+2.29	+24.47	72.57	+1.95	+20.59	70.36	+1.98	+21.55
F-test	S								
Ed. (±)	1.036								
C. D. (P = 0.05)	2.195								

Table 6. Effect of GA and CMC on firmness of Button Mushroom during storage.

Samples	**Storage (Days)**			
	0	**4**	**8**	**12**
C	3	2.9	2.7	2.4

A	3	3	2.9	2.8
B	3	2.9	2.7	2.3
F-Test	S			
S. Ed. (±)	0.037			
C.D. (P=0.05)	0.076			

Table 7. Effect of GA and CMC on Total Plate Count of Button Mushrooms during storage.

Sample	**Storage (Days)**			
	0	**4**	**8**	**12**
C	2.77	3.07	4.11	5.24
A	2.66	3.13	3.51	3.76
B	2.67	3.51	3.62	3.95
F- test	NS			
S. Ed. (±)	0.239			
C. D. (P = 0.05)	0.508			

Table 8. Effect of GA and CMC on Total Yeast and Mold Count of Button Mushrooms during storage.

Samples	**Storage (Days)**			
	0	**4**	**8**	**12**
C	1.41	2.82	3.56	4.57
A	1.35	1.95	2.60	3.15
B	1.38	1.94	2.80	3.93
F- test	S			
S. Ed. (±)	0.182			
C. D. (P = 0.05)	0.386			

APPENDIX

Table A1 Effect of storage GA and CMC on weight loss (in %) of Button Mushroom.

Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**	S. Ed. (±)	C.D. at 5%
Treatment	2	0.10	0.05	7.254060325	4.26	**S**	0.060	0.127
Error	9	0.06	0.01	-	-	-	-	-
TOTAL	11		-	-	-	-	-	-

Table A2 Effect of GA and CMC on Moisture content (in %) of Button Mushroom .

Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**	S. Ed. (±)	C.D. at 5%
Treatment	2	5.40	2.70	3.679412365	4.26	**NS**	0.606	1.285
Error	9	6.61	0.73	-	-	-	-	-
TOTAL	11		-	-	-	-	-	-

Table A3 Effect of GA and CMC) on Ash content (in %) of Button Mushroom.

Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**	S. Ed. (±)	C.D. at 5%
Treatment	2	0.04	0.02	8.735678028	4.26	**S**	0.036	0.076
Error	9	0.02	0.00	-	-	-	-	-
TOTAL	11		-	-	-	-	-	-

Table A4 Effect of GA and CMC on Protein content (gm/100gm) of Button Mushroom.

Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**	S. Ed. (±)	C.D. at 5%
Treatment	2	0.04	0.02	2.88143762	4.26	**NS**	0.058	0.123
Error	9	0.06	0.01	-	-	-	-	-
TOTAL	11		-	-	-	-	-	-

Table A5 Effect of GA and CMC on Color of Button Mushroom.

Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**	S. Ed. (±)	C.D. at 5%
Treatment	3	636.76	212.25	131.9561242	4.07	**S**	1.036	2.195
Error	8	12.87	1.61	-	-	-	-	-
TOTAL	11		-	-	-	-	-	-

Table A6 Effect of GA and CMC on Firmness (Newton) of Button Mushroom.

Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**	S. Ed. (±)	C.D. at 5%
Treatment	2	0.04	0.02	8.735678028	4.26	**S**	0.037	0.076
Error	9	0.02	0.00	-	-	-	-	-
TOTAL	11		-	-	-	-	-	-

Table A7 Effect of GA and CMC on TPC of Button Mushroom.

Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**	S. Ed. (±)	C.D. at 5%
Treatment	2	0.59	0.30	2.5759463	4.26	**NS**	0.239	0.508
Error	9	1.03	0.11	-	-	-	-	-
TOTAL	11		-	-	-	-	-	-

Table A8 Effect of GA and CMC on TYMC of Button Mushroom.

Source	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**	S. Ed. (±)	C.D. at 5%
Treatment	2	1.44	0.72	10.88411615	4.26	**S**	0.182	0.386
Error	9	0.60	0.07	-	-	-	-	-
TOTAL	11		-	-	-	-	-	-