

# Microbial and Sensory Stability of Cauliflower for 180 Days Preserved Through Hurdle Technology

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## Abstract

Fresh cauliflower were preserved by combinations of hurdles i.e. blanching through different treatments- B1-98°C for 30 sec., B2-98°C for 60 sec., B3-99°C for 30 sec., B4-99°C for 60 sec., B5-100°C for 30 sec., B6-100°C for 60 sec., followed by dipping into 0.25% potassium metabisulphite for 10 minutes, among above 6 treatments, successful blanching treatment was selected. Then blanched cauliflower were steeped into different concentrations and combinations of preservatives - P0 (Control sample- fresh without treatment), P1[8% Salt+500 ppm (parts per million) Potassium metabisulphite+100 ppm Sodium benzoate], P2 (10% Salt+400 ppm Potassium metabisulphite+200 ppm Sodium benzoate), P3(12% Salt+300 ppm Potassium metabisulphite+300 ppm Sodium benzoate), P4 (8% Salt+ 0.3% Citric acid+300 ppm Potassium metabisulphite+300 ppm Sodium benzoate), P5 (10% Salt+0.2% Citric acid+400 ppm Potassium metabisulphite+200 ppm Sodium benzoate) and P6 (12% Salt+0.1% Citric acid+500 ppm Potassium metabisulphite+100 ppm Sodium benzoate). Steeped cauliflower were aseptically packed into food grade polyethylene pouches and stored at two temperatures T1 (ambient temperature- 30-37°C) and T2 (refrigeration temperature- 5-7°C) for different time intervals i.e. 0, 30, 60, 90, 120, 150 and 180 days respectively. Thus there are 14 combinations of treatments under study were- P0/T1, P0/T2, P1/T1, P1/T2, P2/T1, P2/T2, P3/T1, P3/T2, P4/T1, P4/T2, P5/T1, P5/T2, P6/T1 and P6/T2 for 180 days of storage period. Among above 6 (B1 to B6) different blanching treatments, the successful blanching treatment was B6-100°C for 60 sec. followed by dipping into 0.25% potassium metabisulphite for 10 minutes. Among above 14 different treatments, the treatments which remained microbial safe till 180 days of storage period were P4/T1 [YMC (Yeast and mold count)- 23.14count/gm, TPC (Total plate count)-46.86 cfu/ml, E.coli(Escherichia coli) -Nil], P5/T2 (YMC- 17.71count/gm, TPC- 14.42 cfu/ml, E.coli-Nil) and P4/T2 (YMC - 8.43 count/gm, TPC-23.43 cfu/ml, E.coli-Nil). Among these three (P4/T1, P5/T2 and P4/T2) treatments, P4/T2 was scored highest in sensory evaluation (color and appearance - 8.0, flavor and texture- 8.2, Body and texture-8.14 and overall acceptability-8.0) in 180 days of storage period. So best hurdle treatment for preservation of cauliflower till 180 days of storage period was P4/T2.

**Keyword:** Hurdle; YMC; TPC; E.coli; ppm

## Introduction

India is a leading vegetable producing country in the world with the production of 113.5 million tons. The country is blessed with the unique gift of nature of diverse climates and distinct seasons, which makes it possible to grow a variety of vegetables. The overall productivity of vegetables is 14.4 tons per hectare. The production of vegetables has taken a big jump due to advent of many hybrid varieties. But our market strategy is not equipped with the handling of large quantity of vegetables as a result quantities of vegetables get spoil. Post harvest losses of horticulture crops are immense. It varies between 5-39% of the total production. The shelf life of perishable vegetables is very low. In brinjal, cauliflower and chilly post harvest losses were found to be high [1].

Preservation involves action taken to maintain foods with desired properties or nature for as long as possible. It lies at the heart of Food Science and Technology and it is the main purpose of Food Processing [2]. The Hurdle concept was first introduced by Professor Lothar Leistner et al. [3]. The hurdle governs many preservation processes. Intense heat (F) preserves canned foods, low water activity prevents microbial growth in dried products, low pH is responsible for prolonged shelf life of fermented foods. This preservation technique is also called combination techniques or barrier technology or *metodascaminados* in Spanish, *tecnologia degli ostacoli* in Italian, *Hurdle Technology* in German. Potential hurdles for food preservation are - Temperature (High or Low), pH (High or Low), Water activity (High or Low),

Modified atmosphere (Co<sub>2</sub>, N<sub>2</sub> etc), Packaging (Vacuum packaging, aseptic packaging, edible coating etc.), Radiation (UV, microwave, irradiation etc), Preservatives (Class I and II). Hurdle Technology is a technology by which 2 or more hurdles are employed in a suitable combination and every hurdle is used at an optimum level so that damage to the overall quality of food is kept to the minimum. Hurdle Technology foods are defined as "Products whose shelf-life and the microbial safety are extended by use of several factors none of which individually would be totally lethal towards spoilage or pathogenic microbes" [4].

## Objectives of the research

- To develop a suitable technology for blanching of cauliflower to inactivate the catalase and peroxidase enzyme.

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- To develop a suitable hurdle technology (appropriate concentration and combinations of preservatives, storage temperatures and storage periods) for blanched cauliflower.
- To study the effect of hurdle technology (different concentration and combinations of preservatives, storage temperatures and storage periods) on the microbial content of preserved cauliflower.
- To study the effect of hurdle technology (different concentration and combinations of preservatives, storage temperatures and storage periods) on the sensory properties of preserved cauliflower.

## Materials and Methods

### Materials used in preservation

**Cauliflower cords:** The cords of cauliflower were procured from local market of Naini.

**Chemicals used in blanching and preservation:** Food grade (potassium metabisulphate, sodium benzoate and citric acid) chemicals were used.

**Polyethylene pouches:** Food grade pouches were used.

**Reagents used in analysis:** Analytical grade reagents were used.

### Method of preservation

First cauliflower head (white curds) after sorting, were cut into 5×3×3 cm. pieces with sharp edged stainless steel knife, then thoroughly washed in tap water and distilled water. After washing, blanched at different- B1-98°C for 30 sec., B2-98°C for 60 sec., B3-99°C for 30 sec., B4-99°C for 60 sec., B5-100°C for 30 sec., B6-100°C for 60 sec., followed by dipping into 0.25% potassium metabisulphite for 10 minutes. Among above 6 (B1 to B6) treatments, successful blanching treatment was selected. Then blanched cauliflower were steeped into different concentrations and combinations of preservatives - P0 (Control sample- fresh without treatment), P1 (8% Salt+500 ppm Potassium metabisulphite+100 ppm Sodium benzoate), P2 (10% Salt+400 ppm Potassium metabisulphite+200 ppm Sodium benzoate), P3 (12% Salt+300 ppm Potassium metabisulphite+300 ppm Sodium benzoate), P4 (8% Salt+0.3% Citric acid+300 ppm Potassium metabisulphite+300 ppm Sodium benzoate), P5 (10% Salt+0.2% Citric acid+400 ppm Potassium metabisulphite+200 ppm Sodium benzoate) and P6 (12% Salt+0.1% Citric acid+500 ppm Potassium metabisulphite+100 ppm Sodium benzoate). Steeped cauliflower were further aseptically packed into food grade polyethylene pouches and stored at two different level of temperatures- T1 (ambient temperature - 30 to 37°C) and T2 (refrigeration temperatures - 5 to 7°C) for different time intervals i.e. 0, 30, 60, 90, 120, 150 and 180 days respectively. Thus there are 14 combinations of treatments under study were-P0/T1, P0/T2, P1/T1, P1/T2, P2/T1, P2/T2, P3/T1, P3/T2, P4/T1, P4/T2, P5/T1, P5/T2, P6/T1 and P6/T2 for 180 days of storage period (where P0, P1, P2, P3, P4, P5 and P6 are different combination of preservatives and T1 and T2 are different level of temperatures, all are explained above). All combinations of treatments were analyzed for their microbial and sensory properties and data obtained after analysis were statistically analyzed.

### Analysis performed

**Blanching test:** Catalase and peroxidase test [5].

**Microbial analysis:** YMC, TPC and E-coli were determined by Conventional method [6].

**Sensory analysis:** Sensory properties (color, flavor, texture and overall acceptability) were determined by 9 Point Hedonic Scale method [7].

**Physical test:** Water activity was determined by using Water Activity Meter [8]. pH was determined by using pH meter (Electronic Corporation of India, Model 5652) as per procedure described in Ministry of Health and Family Welfare, Manual of methods of analysis of foods- Fruit and Vegetable Products [9].

**Statistical analysis:** Obtained data were analyzed for ANOVA (3 Way Classification) and critical difference (C.D.) technique, described by Imran and Coover [10]. In statistical analysis, data used were average of replicates, total no. of treatments combinations were 14 - P0/T1, P0/T2, P1/T1, P1/T2, P2/T1, P2/T2, P3/T1, P3/T2, P4/T1, P4/T2, P5/T1, P5/T2, P6/T1, P6/T2 (where P0, P1, P2, P3, P4, P5 and P6 are different combination of preservatives and T1 and T2 are different level of temperatures, all are explained in Method of preservation). Level of significance was checked at 5% probability level.

## Results

### Blanching test of cauliflower

Result of blanching treatment are given in Table 1. The successful blanching treatment (catalase and peroxidase test found negative) was B6-100°C for 60 sec., followed by dipping into 0.25% potassium metabisulphite for 10 minutes

### Microbial analysis of preserved cauliflower

Scores of microbial analysis (YMC, TPC and E.coli) of preserved cauliflower are given in Table 2.

**YMC analysis:** Treatments in which average YMC were found lowest with a storage period of 180 days are P4/T1 23.14 count/gm), P5/T2 (17.71 count/gm) and P4/T2 (8.43 count/gm). There were significant difference between YMC of treated samples due to combination of preservatives and storage temperatures while there was not significant difference due to days of storage at 5% probability levels.

**TPC analysis:** Average TPC count of the treatment P5/T2 (14.42 cfu/ml) was found lowest in comparison of other treatments in a storage period of 180 days. There were significant difference between TPC scores of treated samples due to combination of preservatives and storage temperatures while there was not significant difference due to days of storage at 5% probability levels.

**E. coli:** E. coli count of fresh and preserved samples were found Nil.

Treatments of Blanching	Catalase Test	Peroxidase Test
B1	Positive	Positive
B2	Positive	Positive
B3	Positive	Positive
B4	Positive	Positive
B5	Positive	Positive
B6	Negative	Negative

B1, B2, B3, B4, B5, B6 are different treatments of Blanching

**Table 1:** Enzymatic activity (presence of catalase & peroxidase enzyme) in blanched cauliflower followed by dipping into 0.25% potassium metabisulphite for 10 minutes.

Treatments with its Shelf life(in days)	YMC/gm	TPC(cfu/ml)	E. coli
P0/T1 -180	32.17*	20.14*	Nil
P0/T2 -180	32.17*	20.14*	- do -
P1/T1 -30	65	47.33	- do -
P1/T2 -60	51	31	- do -
P2/T1 -60	35.75	36.25	- do -
P2/T2 -90	26.8*	25*	- do -
P3/T1 -90	52	40.4	- do -
P3/T2 -120	47.5	25.5*	- do -
P4/T1 -180	23.14*	46.86	- do -
P4/T2 -180	8.43*	23.43*	- do -
P5/T1 -150	40.29	34.28	- do -
P5/T2 -180	17.71*	14.42*	- do -
P6/T1 -120	28.45*	27.33*	- do -
P6/T2 -150	26.5*	21.57*	- do -

YMC/gm-Yeast & mold count/gm; TPC (cfu/ml)-Total plate count (colony formation unit/ml); E. coli- Escherichia coli; All values are MEAN; \*Significant values.

**Table 2:** Scores of microbial analysis (YMC, TPC & E. coli) of preserved cauliflower in different treatments with its shelf life.

### Sensory analysis of preserved cauliflower

Scores of sensory analysis are given in Table 3. In preserved samples, treatment P4/T2 scored highest in color and appearance (8.0), flavor and taste (8.2), body and texture (8.14) and overall acceptability (8.0) with a storage period of 180 days. There were significant difference between scores of color and appearance, flavor and taste, body and texture and overall acceptability scores of treated samples due to combination of preservatives and days of storage while there was not significant difference due to storage temperatures at 5% probability levels.

### Physical analysis of preserved cauliflower

Scores of water activity and pH of treated samples are given in Table 4. Lowest water activity (0.63%) and pH (3.3) were found in P4/T2 in a storage period of 180 days. There were significant difference between water activity and pH scores of treated samples due to combination of preservatives and storage temperatures while there was not significant difference due to days of storage at 5% probability levels.

## Discussion

### Blanching test

During blanching the catalase and peroxidase enzyme was inactivated through treatment B6 (blanching cauliflower pieces at 100°C for 60 sec. in boiling water) followed by dipping into 0.25% potassium metabisulphite for 10 minutes. The results are in agreement of previous finding of Singh [11]. Srivastava and Nath [12] also observed the same result with no difference in blanching time followed by steeping in different concentration of potassium metabisulphite like 0.25%, 0.5% and 0.75%.

### Microbial analysis

**YMC analysis:** In case of YMC analysis, the increase in YMC was observed in all treatments at both the temperatures. In most of the treatments YMC were found above from the standard (as per Food Safety and Standard Authority of India, 2006-Yeast/Mold not more than 100 count/gm) [13] with increase in storage period, which may be attributed during addition of preservatives or during packaging which could have been a carrier of microbes. While in some treatments counts remained under control as per above mentioned standard till 180 days of storage, it might be due to better handling procedure or different

concentration and combinations of class I and II preservatives and low temperature of storage. The results are in agreement of previous finding of Gould [14], observed that the food preservation through hurdle technology cause interference with the homeostasis of yeast and mold. Alzamora et al. [15], also noticed that yeast and mould counts remained below 100 cfu/gm during 4 months of storage of pineapple slices preserved through hurdle technology at 5°C. Lopez-Malo et al. [16], preserved papaya through hurdles technology, found yeast and mold counts < 10 CFU/g during 5 months storage at 25°C.

**TPC analysis:** In case of TPC analysis, the increase in count was observed in all treatments at both the temperatures, while TPC of all the preserved cauliflower found within standard (as per Food Safety and Standard Regulation, 2010- TPC not more than 1000 cfu/ml) [13] till 180 days of storage period but because of YMC of all the preserved sample (except treatments- P4/T1, P5/T2 and P4/T2) were found above from the above mentioned standard of YMC in 180 days of storage period so all the preserved samples were discarded one by one on the basis of their YMC and not considered for further analysis of sensory. The results of TPC are in agreement of previous findings of Alzamora et al. [15] noticed that TPC remain below 100 cfu/ml during 4 months of storage of pineapple slices preserved through hurdle technology

Treatments with its Shelf life (in days)	Flavor & Body & Overall acceptability	Color & appearance	Taste	Texture
P0/T1 -180	9*	9*	9*	9*
P0/T2 -180	9*	9*	9*	9*
P1/T1 -30	7	7.3*	7	7
P1/T2 -60	6.66	7.8*	7.2*	7
P2/T1 -60	6	6.66	6.66	6
P2/T2 -90	6	6.75	7	6.25
P3/T1 -90	6.25	7	6.75	6.25
P3/T2 -120	6.6	7.4*	6.8	6.8
P4/T1 -180	7.14*	7.43*	7.28*	7.14*
P4/T2 -180	8*	8.2*	8.14*	8*
P5/T1 -150	7	7.16*	7.16*	7
P5/T2 -180	7.71*	8.14*	7.42*	7.85*
P6/T1 -120	6	6.8	6.6	6.6
P6/T2 -150	7.16*	7.5*	7	7.3*

All values are MEAN; \*Significant values

**Table 3:** Scores of sensory analysis of preserved cauliflower in different treatments with its shelf life.

Treatments with its Shelf life(in days)	Water activity (%)	pH
P0/T1 -180	0.98*	6.2*
P0/T2 -180	0.98*	6.2*
P1/T1 -30	0.78	4.5
P1/T2 -60	0.74	4.2
P2/T1 -60	0.71	4.4
P2/T2 -90	0.69*	4.14
P3/T1 -90	0.76	4.2
P3/T2 -120	0.74	4.0
P4/T1 -180	0.67*	3.5*
P4/T2 -180	0.63*	3.3*
P5/T1 -150	0.74	3.9*
P5/T2 -180	0.66*	3.7*
P6/T1 -120	0.69*	4.04
P6/T2 -150	0.67*	3.8*

All values are MEAN; \*Significant values.

**Table 4:** Scores of Water activity (%) & pH of preserved cauliflower in different treatments with its shelf life.

at 5°C. Chirife and Guillermo [17] stated that food preservation by combined methods consists of a combination of various parameters also called hurdles may act synergistically to inhibit (or retard) bacterial growth resulting in stable products at room temperature. Barwal et al. [18], preserved cauliflower by using hurdle technology, by different concentrations and combinations of salt (5, 10, 15%), potassium metabisulphite (KMS-0.2%), and citric acid (1.0%) after blanching. The cauliflower steeped in 10 and 15% salt containing 0.2% KMS were chemically, sensory microbial safe among all treatments during the entire period of storage.

**E coli:** In the present investigation *E. coli* were found to be absent in fresh as well as preserved cauliflower samples. This result is also supported by Food Safety and Standard Regulation 2010- *E. coli*-must be Nil [13]. This indicates that the cauliflowers which were used in preservation were free from fecal contamination and also proper hygienic precautions had been taken during preservation as well as during packaging of treated samples.

### Sensory evaluation

In sensory evaluation, the difference and decrease in color and appearance, flavor and taste, body and texture and overall acceptability scores were observed which may be attributed due to increase in microbial count with increase in storage period. But at the same time, treatments P4/T1, P5/T2 and P4/T2 which remained microbial safe till 180 days of storage period were scored highest among all treatments and from 3 of them, P4/T2 was scored highest in sensory evaluation in 180 days of storage period. The results are in agreement of previous finding of Pruthi [19], the vegetables like potatoes, carrot, cauliflower, cabbage, bitter guard, peas, mushroom and animals foods (meat, fish and poultry) preserved in an acidified sulphited brine solution through steeping can be used for pickling or home cooking after leaching out the salt and acid. Barwal et al. [18] standardized the low cost and low energy processing technology for preservation of cauliflower involving different concentration and combination of salt (5-10%), potassium metabisulphite (0.2%) and citric acid (1%) after blanching. The preserved cauliflower was accepted in sensory evaluation after 90 and 180 days of storage by reconstituted in running water for half an hour and evaluated for the preparation of pickle and pakora.

### Physical analysis

In physical test, the reduction in water activity and pH of preserved sample were found as compare to initial or fresh commodity. Reduced water activity and pH were found effective for long time storage. The results are in agreement of previous finding of Vibhakara et al. [20], maintenance of pH < 4.5 helped in controlling multiplication and survival of spores and also helpful in achieving shelf stability. Low pH and water activity solutions are used as antimicrobial agent or as antioxidant to prevent browning, to reduce discoloration of pigments, and to protect against loss of flavor, changes in texture [21].

### Conclusion

All the hurdles (treatments combination) were not effective for preservation of cauliflower till 180 days of storage period. Only 3 treatments - P4/T1, P4/T2 and P5/T2 were microbial safe till 180 days and among these 3, only P4/T2 was found best in sensory evaluation sin 180 days of storage period.

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