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Quality aspects of cauliflower during storage

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Abstract: Studies were carried out to changes in the Bio chemical and Microbiological quality of the cauliflower has been changed during storage which was ranges from 2 ± 1° C to 12 ± 1° C for 3 weeks of incubation period. The cauliflower consist of Phenolic compounds such as Ferulic acid, Chlorogenic acid, Gallic acid and Catechin contents were decreased drastically during the irrespective treatment and packaging of the cauliflower but the proper packaging process of cauliflower retained the pure quality of the Phenolic content compared to untreated packaging. Commonly cauliflower have increased Mesophilic aerobes Microflora which was reduced during the storage condition in LDPE bags which was build up by carbon dioxide has an anti microbial activity to reduce the Microbial flora on the packaging material of the cauliflower.

Keywords: Cruciferous, phytochemicals, low- density polyethylene (LDPE) broccoflower, romanesco and TSS

Introduction

Cauliflower, like broccoli and cabbage, belongs to the cruciferous family of vegetables which has been shown to be effective in fighting certain forms of cancer. Cauliflower is so closely related to broccoli that both are designated as the same variety of the cruciferous family shares not only the wonderful phytochemicals and also contains nutritive value of Vitamin A, Thiamine, Riboflavin, Niacin, Vitamin C, Calcium, Iron, Phosphorous and Fat to help fight diseases (Fennema and Owen , 1996).

The main bioactive phytochemicals in fruit and vegetables include polyphenols, terpenoids, glucosinolates and other sulphur-containing compounds. Clinical studies support that the role of plant food phytochemicals as health-promoting food constituents (Scalbert *et al*., 2002).

Cauliflower varieties range from very-early maturing (less than 60 days fromtransplanting to maturity) to late-maturing (over 100 days). Several varieties are recommended for both fresh-market and processing use. There are several novelty varieties of cauliflower, including Broccoflower (green cauliflower) and Romanesco. These novelty varieties account for a very minor portion of the market. Most cauliflower is transplanted in the field with seedlings that are either greenhouse-grown or field-grown. Some cauliflower also is direct-seeded. Greenhouse-grown transplants (plug plants) are planted with the soil and roots intact (Belscher and Marcy, 1994).

The quality of cauliflower as influenced by film wrapping during shipment. They found that slight or no changes in chemical quality attributes, except for a increase in TA (Titrable Acidity), were detected during shipment and shelf life stimulations of cauliflower as expected in a non climacteric vegetable. No significant changes in external inflorescence colour were detected at any point during any treatment and no significant differences between treatments or gas compositions within packages effects on physiological disorders and decay development were found. They also concluded that LDPE film should be a good substitute for PVC in wrapping cauliflower heads, mainly for shipment to those countries where the use of PVC in horticultural products is currently forbidden. Wrapping the product in different polymeric films is a frequently used to reduce water loss (i.e. to retain firmness and decrease wilting) but this practice often promotes decay, possibly due to increased free-water in the package and on the surface of the cauliflower (Artes and Martinez, 1999).

In general, freshly harvested fruits and vegetables especially Cauliflower contain more vitamin C than those held in storage and they show a gradual decrease in Ascorbic acid content as the storage temperature or duration increases. Vitamin C is most sensitive to destroy the product is subjected to unfavorable handling and storage conditions. Losses are enhanced by extended storage, higher temperatures, low relative

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humidity, physical damage and chilling injuries. Temperature management is the most important tool to extend shelf-life and indirectly delay losses in nutrients such as vitamin C. Accelerated losses in vitamin C at higher temperatures has been shown in many types of fruits and vegetables (Lee and Kader, 2000).

The common commercial storage conditions of 0°C and 95–100% relative humidity of post harvest cauliflower has an expected shelf life of 3–4 weeks. The effect of controlled atmosphere on the storage of cauliflower greatly extended the shelf life the products. 10% CO_2 and pre treatment at 15% CO_2 caused damage to the tissues, resulting in yellowing softening and development of microorganisms (Romo-parado *et al*., 1989).

The growth of *Aeromonas hydrophila* on fresh vegetables stored under controlled atmosphere at 4°C contained an initial inoculum of 103 to 104 *Aeromonas hydrophia* CFU /g. Populations increased to 105 to 106 CFU/g during the first 7 days of storage. The shrink wrapped vegetables indicated that populations of natural Microflora on vegetables tended to increase more rapidly compared to those on unwrapped vegetables under controlled atmosphere conditions. Naturally occurring aerobic microorganism do not have a competitive advantage and difference in vegetable composition and naturally occurring Microflora would also be expected to influence rates of microbial growth (Verhoeven, 1997).

Materials and Methods

Cauliflowers were collected at optimum mature stage from local area of Gandhi Market, Tiruchirappalli, Tamil Nadu, India. Cauliflowers were pre cooled overnight at 4-6°C. Then they were thoroughly washed with potable water followed by dip in chlorinated water (100 ppm). The control and treated cauliflower were packed in Light Density Polyethylene bags (150 gauge and 100 gauges) and Wrapped in cling film. The samples were stored at 2±1°C and 12±1°C. Samples were drawn at periodical intervals and analyzed for Texture, Colour, Acidity, Total Soluble Solid (TSS), Ascorbic acid, Total sugars, Total Phenolics and Microbiological quality.

Chemical analysis

Parameters indicating the deterioration in the stored cauliflower were studied and included by Titrable acidity by titration with 0.1N NaOH, Total Soluble solids (TSS) using Refractometer and expressed as °Brix, Moisture content and Ascorbic acid Were determined by direct titration method using 2,6 dichlorophenol Indophenol dye as indicator.

Extraction of phenolics

Weighed 5 g cauliflower pulp and dissolved in 25 ml of 80% methanol. The samples were extracted by continuous stirring for 1 hour at room temperature. The supernatant was filtered through a nylon cloth and the residue was resuspended in methanol. The extraction process was repeated twice. The supernatants were pooled and volume measured and taken for analysis.

Estimation of total phenolics

Total phenolics were determined calorimetrically at 765nm by using methanolic extracts by Folin-Ciocalteu method for fresh and stored samples (Montedoro *et al*., 1992)

Estimation of free sugars

Extraction of sugars

Weighed 5 g cauliflower pulp and dissolved in 25 ml of 70% ethanol. The samples were extracted by continuous stirring for 1 hour at room temperature. The supernatant was filtered through a nylon cloth and the residue was resuspended in methanol. The extraction process was repeated twice. The supernatants were pooled and volume measured and taken for analysis.

Estimation of total sugars

The total sugar was determined by using Anthrone method. Pipetted out 0.1- 0.5 ml of the working standard and known volume of the samples in triplicates to different tubes. The volume was made up to 0.5 ml with distilled water. To this, added 0.3 ml of 5% phenol and mixed well. Added 2 ml of concentrated Sulphuric acid to all the tubes and incubated in room temperature for 20 min. The color developed was read at 480 nm against a reagent blank.

Microbiological studies

The Microbial profile of fresh cauliflower and during storage was studied. Ten gram of sample was stoamchered and serially diluted with saline. Serially diluted samples (1.0 ml) were pour plated on Plate Count Agar, Potato Dextrose Agar and MacConkey agar to determine Mesophilic aerobes, yeasts ands molds and Coliforms. The plates were incubated, observations recorded and results expressed as colony forming units (CFU) per gram.

Results

The present study revealed that the changes in bio chemical and Microbiological quality of the cauliflower during 6 stages of development resulting in increasing trend of all the parameters like TSS , ascorbic acid, total sugars, reducing sugars and Phenolic compounds (Table 1).

Table 1. Changes in chemical parameters during different stages of development

Stages of Cauliflower	TSS °Brix	Ascorbic acid (mg/100g)	Total Sugars (g/100g)	Reducing sugars (mg/100g)	Total Phenolics (mg/100g)
1	7.21	63.43	1.9	0.8	153.46
2	5.10	62.25	5.3	1.8	146.00
3	6.30	68.33	2.7	1.5	163.02
4	6.72	62.18	2.4	1.2	154.85
5	7.65	74.85	7.4	2.9	153.94
6	8.44	89.82	4.5	2.0	235.18

During storage condition of Cauliflower ranges from 2 ±1°C to 12 ±1°C for 3 weeks of period was found that there were no significant changes in moisture and total soluble solids content in cauliflower. But the content of ascorbic acid was decreased significantly at 12 ±1°C when compared to 2 ±1°C (Table 2).

Table 2. Changes in quality of cauliflower during storage at 2 ±1°C and 12 ±1°C

Parameters	Initial		1st week		2nd week		3rd week	
	2°C	12°C	2°C	12°C	2°C	12°C	2°C	12°C
Moisture (%)	92.68	92.68	92.07	92.56	90.57	91.50	89.78	-
TSS °Brix	7.70	7.70	7.62	6.79	7.27	6.10	7.56	-
Acidity (%)	0.15	0.15	0.16	0.13	0.37	0.28	0.25	-
Ascorbic acid (mg/100g)	62.97	62.97	51.86	39.08	48.72	40.32	43.11	-

The cauliflower stored at 12 ±1°C got fungal infection on the surface during the 3rd week of storage. There was almost 50% reduction in ascorbic acid content at 12 ±1°C at the end of 2nd week of storage compared to around 20% in case of cauliflower stores at 2 ±1°C. The fungal growth on the surface of cauliflower initiated after 10 days of storage at 12 ±1°C. Hence it was found that cauliflower stored best at 2 ±1°C and the cauliflower stored at 12 ±1°C lost its marketability within 2 weeks of storage. Cauliflower stored as open control without any packaging became shriveled, browning and blackening of the florets and lost its marketability within a week at both the temperatures.

The phenolic compounds were identified in cauliflower such as ferulic acid, chlorogenic acid, gallic acid and catechin. There was generally decreasing trend during the different stages of the development but in storage, the phenolic content decreased drastically irrespective of the treatment and packaging (Fig 1). Among the packaging, treated cauliflower retained the phenolic compounds better than untreated (Table 3).

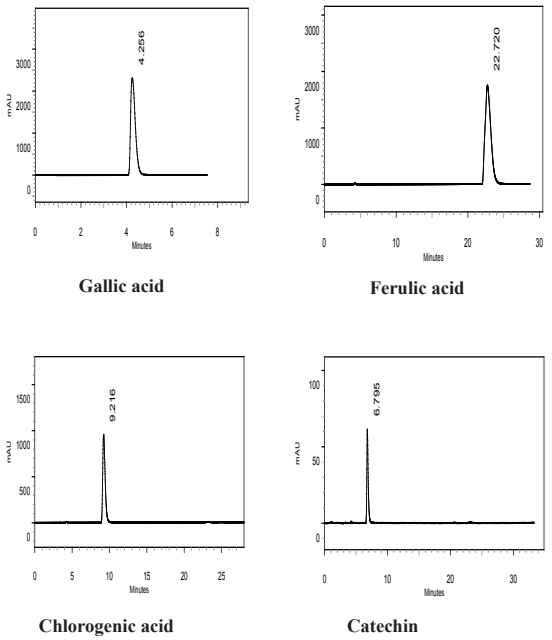

Figure 1. Phenolic acid standards

Table 3. Influence of storage on phenolic content (mg/100g)

Sample	Initial	After 2 weeks	After 3 weeks
Cling film -control	153	46.02	46.93
Clingfilm- Treated		50.94	69.44
LDPE control		38.20	59.80
LDPE treated		53.17	66.17

The content of Ascorbic acid and Total Soluble Solids (TSS) were found in low at 2 ±1°C during storage that retained ascorbic acid better when the cauliflowers were packed in LDPE bags compared to those wrapped with cling film (Table 4). Similarly the TSS increased more in case of cling film than LDPE packed cauliflowers, which might be due to reduced metabolic activity in LDPE packed ones due to the modified atmosphere created within the packs.

Table 4. Influence of storage on ascorbic acid

Sample	Initial (mg/100g)	2nd week (mg/100g)	3rd week (mg/100g)
Cling Film Control	62	60	41
Cling film test		59	43
LDP control		62	54
LDP test		60	52

The texture of the cauliflower decreased in case of all the treatments. Among the treatments, the cauliflower packed in LDPE retained the texture better at the end 3 weeks of storage. The LDPE

packed cauliflower, both treated and untreated retained the texture values close to the initial values up to 2 weeks of storage and decreased thereafter. The total sugars decreased initially but at the end of 3rd week of storage, the sugar content was increased. The increase in sugar or starch metabolism was found to be more in cling film wrapping (Table 5). In case of reducing sugars, generally there was decreasing trend (Table 6).

Table 5. Changes in Total sugars during storage of cauliflower at 2±1°C (g/100g)

Sample	Initial	2nd week	3rd week
Cling film- control	7.6	5.60	9.70
Cling film- treated		5.74	7.85
LDPE- control		6.12	7.04
LDPE- treated		5.70	6.36

Table 6. Changes in reducing sugars during storage of cauliflower at 2±1°C (mg/100g)

Sample	Initial	2nd week	3rd week
Cling film- control	2.67	2.79	2.53
Cling film- treated		2.03	2.36
LDPE- control		2.04	2.00
LDPE- treated		1.98	2.27

The cauliflower had general Microflora of Mesophilic aerobes which increased during storage. The number of microbial flora was reduced in LDPE compared to cling film wrapping. But in all the cases, the microbial count was within the threshold limit of 10^6. The yeasts and molds decreased during storage in LDPE bags, which could be due to the antimicrobial activity of the carbon dioxide build up within the packs (Table 7 and 8).

Table 7. Mesophilic aerobes count (CFU)

Sample	Initial			2nd week			3rd week		
	10^{-2}	10^{-4}	10^{-6}	10^{-2}	10^{-4}	10^{-6}	10^{-2}	10^{-4}	10^{-6}
Cling film- control	55	23	6	110	82	44	TNTC	180	16
Cling film- treated	62	11	3	70	50	30	35	4	0
LDPE- control	32	18	1	50	20	12	195	30	3
LDPE- treated	26	8	0	18	7	3	70	17	0

(TNTC: Too Numerous To Count)

Table 8. Molds and yeast (CFU)

Sample	Initial			2nd week			3rd week		
	10^{-2}	10^{-4}	10^{-6}	10^{-2}	10^{-4}	10^{-6}	10^{-2}	10^{-4}	10^{-6}
Cling film- control	61	13	4	125	42	18	70	30	9
Cling film- treated	52	8	0	130	17	9	7	1	0
LDPE- control	32	12	1	48	18	3	58	4	2
LDPE- treated	18	8	0	14	3	0	32	5	0

Discussion

Cauliflower is extremely perishable. The storage temperature should be between 0-4°C. Storage at high temperature rapidly causes deterioration of cauliflower quality and shelf life. Cauliflower should be harvested either early in the morning or in the evening. Cauliflower should never be allowed to roll over and the white curd should not touch any surface, which will lead to decay and browning (Boyette *et al*., 1996).

The quality of the cauliflower during storage, O_2 levels of between 2 % and 8% and CO_2 levels less than 5 % have been recommended. However in some reports on Controlled atmosphere storage of cauliflower, adverse effect or very small beneficial effects on ethylene and respiratory metabolism and external quality were found (Berrang *et al*., 1990)

Temperature management is the most important tool to extend shelf life and maintain quality of fresh fruits and vegetables. Delays between harvesting and cooling or processing can result in direct losses due to eater loss and decay and indirect losses such as loss in flavour and nutritional quality (Kader *et al*., 1978). Farmers need to be educated about different non-chemical control methods and encouraged to adopt Integrated Pest Management (IPM) practices is in need of in-depth research on non-chemical management of pests in vegetables wherein pest infestation is relatively high.

It was found that cauliflower could be stored for a period of 3 weeks in a good and marketable condition and in microbiologically safe condition, when packed in LDPE bag of 150 gauge thickness and stored at 2 ±1°C. Yellowing and browning of the heads were the only physiological disorders detected. Yellowing is a disorder developed in the inflorescence due to the solar radiation.

Browning or black spots can be due to bruises and pressure points. Later the affected points turn dark brown to black. When the symptoms progress, a fungal attack is seen. At the end of cold storage, a slight increase in the severity of yellowish and brownish spots was observed in all the heads wrapped with cling film. After 4 weeks of storage, decay started to appear as a very small black stain on the inflorescence, which may be due to the high relative humidity within the packaging (Ceponis,1987).

Post harvest handling is the final stage in the

process of producing high quality fresh products. Being able to maintain a level of freshness from the field to the dinner table presents many challenges. A grower, who can meet these challenges, will be able to expand his or her marketing opportunities and be better able to compete in the market place (Suslow and Cantwell, 1999).

Many different testing procedures exist for the detection of microorganisms such as total plate counts or aerobic plate count. The microbial count was within the threshold limit of 10^6 given an idea of the extent of microbial limited value in terms of assessing food safety. A wide range of microorganisms exist naturally on the surfaces of fruits and vegetables and they will colonize a growing medium. These types are useful for monitoring the hygiene system or evaluating the impact of certain sanitary measures (Albrecht *et al*., 1995). As a result, the best strategy is to minimize the risk and to prevent as much contamination as possible. An important aspect in any program of good agricultural or manufacturing practices is to have a tracing system. This is necessary corrective measures can be undertaken as soon as possible. In spite of these limitations, keeping records may help to reduce the population at risk and should complement all preventive measures.

It was concluded that there are only marginal benefits of using Controlled atmosphere to cauliflower. Air storage at 0.3°C should provide good outturn condition and adequate shelf life so long as products are handled correctly and water loss is minimized.

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