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Osmo-drying and quality evaluation of cauliflower genotypes

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Abstract

In this investigation, twenty-five genotypes of cauliflower (*Brassica oleracea* L. var. *botrytis*) were selected. The samples were uniformly processed keeping all the processing variables (thermal and drying time) constant and dried to a shelf stable product. The effects on moisture content, ascorbic acid, rehydration ratio, antioxidant capacity and sensory acceptability of the product obtained was investigated initially and at the end of storage period. The initial moisture content in the dried cauliflower samples presented values around 4% which increased to approximately 7% at the end of storage period of 180 days. The initial values for ascorbic acid were found to be in the range of 33.8-41.7 mg/100 g DW, while on the final day of storage lowest (30.4 mg/100 g DW) was observed in entry 2020CAUMVAR4. The difference between genotypes was noted for rehydration ratio. Remarkably, good rehydration ratio >3 was observed in all cauliflower genotypes. However, it was observed that 2018CAUMVAR1 performed the best in terms of rehydration ratio and sensory acceptability. The results are useful to identify cauliflower genotypes more amenable for processing.

Key words: Cauliflower, Drying, Shelf life, Quality, Moisture content, Sensory

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is an important vegetable belonging to Brassicaceae family. It is quite popular and was being grown in 0.46 mha area with production of 8.67 mt (HORTSTAT 2018). In India, West Bengal, Madhya Pradesh, Bihar, Uttar Pradesh, Haryana, Odisha, Gujarat, Chhatisgarh, Assam and Punjab states are leading growers and producers of cauliflower. Globally, cauliflower grows best between the latitudes 11-60 °N with average temperature ranging from 5-8 °C to 25-28 °C, and tolerates temperature from -10 °C to 40 °C for a few days during the vegetative growth period (Singh et al. 2018). It is a widely consumed vegetable due to its unique mild taste and curd texture, utilized in different savory preparations. Importantly, this crucifer vegetable is a storehouse of different bioactive and nutritive compounds like vitamin C, polyphenols, ascorbic acid, glucosinolates, dietary fibre, minerals, and even low amounts of carotenoids (Volden et al. 2009a, 2009b; Hurtado et al. 2012; Picchi et al. 2012; Reis et al. 2015; Giuffrida et al. 2018; Gonzalez et al. 2021). These bioactive compounds are beneficial for maintenance of human health as well as help in prevention of onset of many chronic lifestyle diseases. However, heavy yield and the resulting market glut often cause huge monetary losses to the growers and farmers. Cauliflower curd can be stored for up to about 20 days with acceptable sensory quality at 0 ÚC storage temperature (Mashabela et al. 2019). However, the lack of cold storage infrastructure in our country leads to huge crop losses. Postharvest loss to the tune of approximately Rs. one lakh crore has been estimated in our country (NAAS 2019). Similarly, higher monetary losses in fresh vegetables during postharvest supply chain are reported from many other countries around the world. Even as minimal processing is gaining market as a convenience food, it is still suitable only in supermarkets of metro cities. Moreover, it is plagued by different limiting factors like texture breakdown, browning, floret opening, off-flavour development and decay etc. which result in a very short shelf life (Hodges et al. 2006; Artes et al. 2007; Licciardello et al. 2013). Cauliflower can also be stored under modified atmosphere packaging (Cantwell and Suslow 2002). However, active modified atmosphere packaging storage involves high cost, careful storage and transportation and low storage potential.

Drying of vegetables is a very apt technology to preserve vegetables for a longer period at significantly cheaper costs. It is practiced since ages to preserve and enhance

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availability for food and nutritional security during lean period. Controlled dehydration yields high quality products at very minimal input costs and hence is a very useful technology to lower postharvest losses and waste as well as enhance nutritional security. It is a very effective method of preservation, particularly due to volume reduction, ease in storage and transportation, cost efficiency, low energy requirements as well as a remarkable extension in storage period. Ranjan et al. (2014) suggested that hot water blanching with 0.125% potassium metabisulphite, microwave blanching for 5 minutes and drying at 65°C was the most optimum treatment for dehydration of cauliflower. On similar lines, Kad et al. (2017) studied effect of different pre-treatments, drying time and temperature on cauliflower. Besides, osmo-convective dehydration techniques, different drying methods and quality assessment of dried cauliflower was also studied by other workers (Thakur and Jain 2006; Manjunatha et al. 2007; Gupta et al. 2012; Kordon et al. 2018; Sharma and Prasad 2018; Singh et al. 2019). The effects of heat treatment like boiling, steaming and sous-vide was done on cauliflower to understand cellular changes occurring during softening and sterol and tocopherol extraction (Nartea et al. 2021). The influence of processing on glucobrassicin content and degradation in cauliflower was studied by Sosinska and Obiedzinski (2011). Similar studies on effect of domestic cooking practices on quality attributes of coloured cauliflower was investigated by Diamante et al. (2021).

However, often batch to batch variations have been observed in storage potential, quality, consumer acceptance, shelf stability and colour of the final product. Thus, this investigation was done to assess the different genotypes for their suitability to processing, as well as record the changes in quality of dried cauliflower such as moisture content, rehydration ratio, ascorbic acid, *in vitro* antioxidant capacity and the sensory acceptability of the dried product during the storage period.

Materials and Methods

Plant materials: Twenty-five entries of cauliflower's varietal/hybrid trials of AICRP-VC were grown at ICAR-Indian Institute of Vegetable Research, Varanasi, UP; and the fresh curds were selected at marketable maturity & brought to laboratory for biochemical assay (Table 1). The curds were immediately cut into uniform size (2.5-3.0 cm) florets for uniform blanching, thoroughly washed to remove any adhering dirt and then blanched in boiling water for 60-90 seconds. The florets were then cooled and dipped into 0.2% potassium metabisulphite solution followed by osmotic diffusion treatment in 3-4% salt solution for 60 minutes. The florets were then transferred to dehydrator trays and dried at 55-60 °C for 10 hours. The florets were cooled to room temperature, packaged and stored at room temperature for 180 days. The observations were recorded initially and at the end of storage period in triplicate.

Table 1: Maturity and yield of the cauliflower entries selected in the current study

S. No.	Genotype	Days taken for 50% curd maturity	Yield (q/ha)
1.	2020CAUMVAR6	69.4	236
2.	2020CAUMHYB7	73.6	302
3.	2020CAUMVAR4	95.5	198
4.	2020CAUMVAR3	97.5	223
5.	2018CAUMVAR4	82.1	178
6.	2019CAUMHYB5	98.7	384
7.	2018CAUMVAR2	86.2	149
8.	2019CAUMHYB1	100.4	394
9.	2020CAUMHYB3	84.3	308
10.	2018CAUMVAR5	84.2	159
11.	2018CAUMVAR7	92.5	184
12.	2018CAUMVAR1	128.5	342
13.	2020CAUMVAR2	95.8	217
14.	2020CAUMHYB6	85.5	270
15.	2018CAUMVAR3	72.3	204
16.	2019CAUMHYB3	78.7	186
17.	2020CAUMHYB1	106.5	248
18.	2020CAUMVAR7	73.6	267
19.	2020CAUMVAR5	75.9	229
20.	2019CAUMHYB2	68.3	310
21.	2020CAUMHYB4	103.6	224
22.	2020CAUMVAR1	110.9	196
23.	2018CAUMVAR6	70.7	178
24.	2019CAUMHYB4	98.7	191
25.	2019CAUMHYB7	95.7	262

Moisture content: Moisture content was assessed in cauliflower floret by gravimetric method in all genotypes (Ranganna 1999). The values were expressed as percentage.

Ascorbic acid: Ascorbic acid content in cauliflower floret was estimated by the titration method using 2,6-dichlorophenol-indophenol dye (Ranganna 1999). Cauliflower was macerated in 3% metaphosphoric acid (MPA), and volume made up with MPA. The solution was titrated with dye till pink colour appeared. The values were expressed as mg/100 g DW.

Antioxidant capacity: The antioxidant capacity was measured by observing the inhibition percent of 2,2 diphenyl-1-picrylhydrazyl (DPPH) radical solution It was expressed as percentage (Brand-Williams et al. 1995).

Rehydration ratio: The rehydration ratio was measured as drained weight of the rehydrated sample to weight of dehydrated sample.

Sensory evaluation: Samples were evaluated for appearance, colour, body and texture, flavor and overall acceptability using 9-point hedonic method (Ranganna 1999). Semi trained panelists scored samples based on hedonic scale: 9- Liked extremely, 8-liked very much, 7- liked moderately, 6-liked slightly, 5- neither liked nor disliked, 4- disliked slightly, 3- disliked moderately, 2- disliked very much, 1- disliked extremely.

Statistical analysis: All data were subjected to one way analysis of variance (ANOVA). Different genotypes were source of variation (p d” 0.05). Data were expressed as mean of three replications ± standard error.

Results and Discussion

Effect on Moisture content: The moisture content of dehydrated produce is a direct indicator of its shelf stability and quality. Non-optimal moisture content above the safe threshold range and the consequent higher water activity causes accelerated microbial attacks and spoilage. Conversely, very low moisture content reduces the quality of the produce due to poor retention of vitamin C, lower rehydration capacity, radical scavenging activity and consumer acceptability. Excessive lower moisture content shows tissue damage, shrinkage and often fails to achieve the desired texture and quality after rehydration leading to lowering of market value. The moisture content in fresh cauliflower florets was found to be around 91-92%. In the present study, initial moisture content in the different cauliflower genotypes after osmo-drying ranged between 3.31-4.18%. The moisture content was found to increase with increasing storage duration. After 180 days of storage, the lowest increase in moisture content was recorded in 2020CAUMHYB7 (6.71%) while the maximum (8.04%) was noted in 2020CAUMVAR5 (Figure 1). Higher moisture content of 9-13.7% was observed in dried cauliflower by Thakur and Jain (2006) after drying time of 8-12 hours of cultivar "Pusa Snowball".

Effect on Ascorbic acid and Antioxidant capacity: Ascorbic acid retention during processing depends on the temperature, drying time and storage period. The change in ascorbic acid content of osmo-dried cauliflower during storage is presented in Figure 2. It was found to decrease with the advancement in storage duration in all the genotypes. However, the decline was very gradual and the dried cauliflower florets showed slight loss (15-25%) in ascorbic acid retention after the initial processing. The maximum ascorbic acid retention was observed in 2019CAUMHYB2 (41.73 mg/100g DW) and 2020CAUMVAR2 (35.01 mg/100 g DW) at initial and end of storage period, respectively. Similar loss in ascorbic acid retention during different intervals of storage was reported by Gupta et al. (2012). They recorded vitamin C retention of about 28-59% and 24-54% after third and fourth month of storage, respectively.

The recovery of dried cauliflower ranged between 9-10%. The radical scavenging activity expressed as antioxidant capacity of dried cauliflower is presented in Figure 3. It is a very important attribute as the free radical scavenging helps to reduce lifestyle immune diseases. Figure 3 shows that DPPH inhibition percentage of stored cauliflower showed lowering by maximum about 33% and lower in comparison to initial values. The maximum scavenging activity was observed in 2020CAUMVAR2 (62.97%), 2019CAUMHYB1 (60.27%) and 2020CAUMVAR1 (57.23%) while least activity (44.12%) was found in 2018CAUMVAR5 on the initial day of storage. On the final day of storage 2019CAUMHYB4 genotype showed highest (47.44%) inhibition percentage.

Effect on Rehydration ratio: Rehydration quality is a very important parameter for dried products, particularly those which are not consumed directly in dry form but after rehydration. The fresh cauliflower genotypes

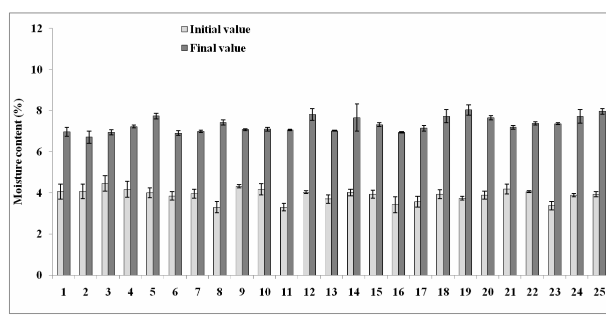

Figure 1: Moisture content (%) in dried cauliflower at initial (0 day) and end (180 day) of the storage period. The values are expressed as mean of three replications ± standard error.

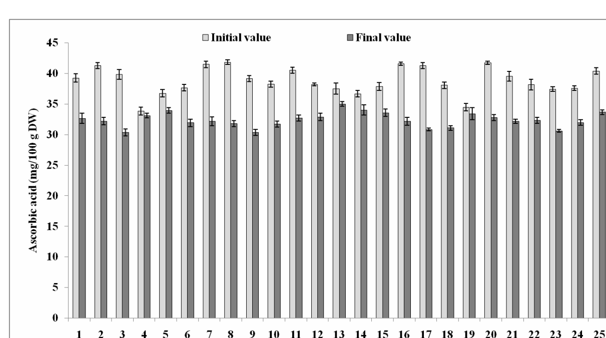

Figure 2: Ascorbic acid (mg/100 g DW) in dried cauliflower at initial (0 day) and end (180 day) of the storage period. The values are expressed as mean of three replications ± standard error.

selected in this study presented 91-92% (w.b.) moisture content in fresh florets which was reduced to about 4% (d.b.) after osmo-drying. This drastic loss causes shrinkage and remarkable size reduction. Ideally, it is desired that the dried produce regains the size, shape, texture, mouthfeel and quality of fresh produce after re-hydration. However, due to damage to cellular structures during drying, it is generally not seen in dried products. Generally, a rehydration value above 3 is considered to be indicative of good reconstitution, texture and quality of the produce. It entails surface wetting, penetration of water, diffusion and equilibration. It is evident from the Figure 4 that the rehydration ratio showed slight decline after 180 days of storage. Remarkably, all cauliflower genotypes showed the rehydration ratio above 3.32. At the initial point, after processing of cauliflower, the rehydration ratio was highest in 2018CAUMVAR1 (6.41), 2020CAUMVAR7 (5.32) and 2018CAUMVAR2 (5.18). The 2018CAUMVAR1 genotype showed 4.42 rehydration ratio after storage while 2019CAUMHYB3, 2018CAUMVAR4, 2020CAUMVAR2 genotypes showed values near 5. Higher porosity and better tissue structure in these genotypes might be the reason for better

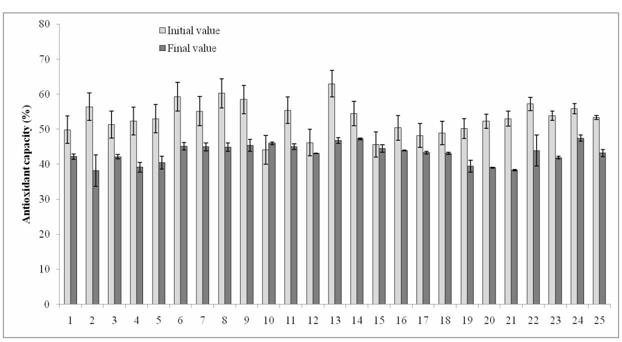

Figure 3: Antioxidant capacity (%) in dried cauliflower at initial (0 day) and end (180 day) of the storage period. The values are expressed as mean of three replications ± standard error.

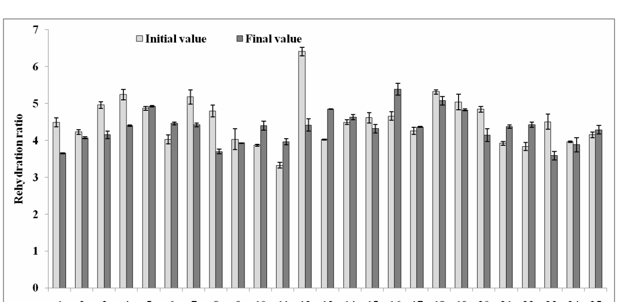

Figure 4: Rehydration ration (%) in dried cauliflower at initial (0 day) and end (180 day) of the storage period. The values are expressed as mean of three replications ± standard error.

rehydration ratio. Cauliflower blanched and then dipped in 2.5% starch solution presented most optimum dried product having high rehydration ratio with good visual colour and appearance (Mishra and Agrawal 2005).

Sensory evaluation: The processing industry is catapulted by the acceptance of final product by the consumers. Hence, it is a very essential estimation for selecting the optimum process or genotype with better processable traits. In this study, the panelists evaluated the final product from 25 genotypes for colour, flavor, appearance, body and texture and overall acceptability. The scoring done on hedonic scale gives an indication for acceptance of the product as the purchase by consumer is mainly done on the visual perception. In this study, sensory evaluation was done at the end of storage period. It is evident from the Figure 5 that none of the sample was marked below 6.5 for any attribute at the end of storage period. All the cauliflower genotypes led to acceptable final dried product. Yet, 2018CAUMVAR1 showed best scores for all sensory attributes assessed like colour (8.33), appearance (8.08), flavor (8.5), body & texture (8.08) and overall acceptability (8.08). This might have been particularly due to the highest rehydration ratio observed in this genotype. It was noted that the genotypes with slight green coloured floret stalk, which is a varietal attribute was scored higher for colour and appearance over creamish or slightly brownish appearance. Some genotypes scored higher in appearance, however at the same time scoring less in flavor and body & texture. This was attributed to the leathery texture in these genotypes as opposed to the fresh like clear crisp mouthfeel in desired dried cauliflower in 2018CAUMVAR1.

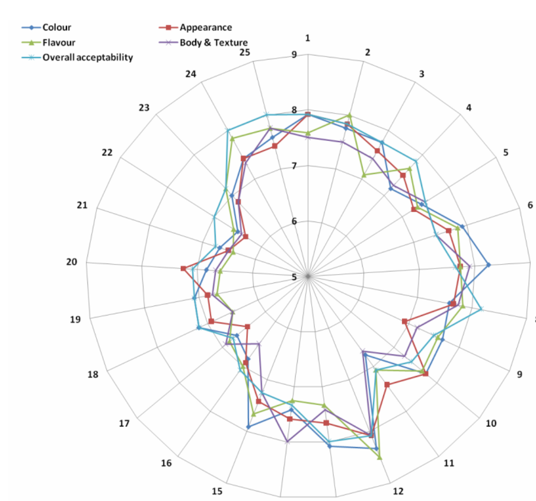

Figure 5: Sensory evaluation of dried cauliflower at the end (180 day) of the storage period

Conclusion

A large intake of cruciferous vegetables is due to widely liked and consumed cauliflower. Hence, this investigation was done to assess the different cauliflower genotypes and identify with maximum sensory acceptance and suitable processable attributes. In this study, we observed that all the cauliflower genotypes presented acceptable dried product for storage and the consequent use after rehydration during storage period. The gain in moisture content at the end of storage of 180 days was within the acceptable range. Genotypes 2020CAUMHYB7, 2018CAUMVAR2, 2019CAUMHYB1 performed well in terms of sensory acceptability at the end of storage. However, 2018CAUMVAR1 genotype performed the best among all the genotypes, particularly showing the maximum rehydration ratio. The visual appearance, colour, flavour, body and texture as well as overall acceptance of the osmo-dried cauliflower prepared from 2018CAUMVAR1 genotype was maximum.

Lkkjka'k

फूलगोभी (*बासिका ओलेरेसिया* एल.वार *बोटराइटीस*) के चयनित 25 प्रभेदों का परीक्षण किया गया। सभी संसाधित परिवर्त्यों (उष्मीय एवं सूखने के समय) को ध्यान में रखकर सभी प्रतिदर्शों को एक समान संसाधित किया गया। नमी की मात्रा एस्कार्बिक एसीड पुनर्जलीकरण अनुपात, प्रति आक्सीकारक क्षमता एवं उत्पाद ग्रहणशील स्वीकार्यता का परीक्षण प्रारम्भ हो तथा भण्डारण काल के अंत में किया गया। फूलगोभी के सूखे प्रतिदर्शों के प्रारम्भिक नमी की उपलब्ध मात्रा लगभग 4 प्रतिशत पाया गया जो औसतन बढ़कर 7 प्रतिशत भण्डारण के अंत में (180 दिनों उपरांत) हो गया। एस्कार्बिक एसीड की प्रारम्भिक मात्रा 33.8–41.7 मिग्रा. प्रति 100 ग्राम, शुष्क भार के मध्य था जबकि भण्डारण के अंतिम दिनों में सबसे कम (30.4 मिग्रा. प्रति 100 ग्राम शुष्क भार) प्रवृष्टि 2020 सी.ए.यू.एम.वी.वी.ए.आर.–4 में पाया गया। पुनर्जलीकरण अनुपात के लिए विभिन्न प्रभेदों में अंतर पाया गया। हालांकि प्रभेद–2018 सी.ए.यू.एम.वी.ए.आर.–1 पुनर्जलीकरण एवं ग्रहणशील स्वीकार्यता के आधार पर सर्वोत्तम पाया गया। यह अध्ययन फूलगोभी के प्रसंस्करण योग्य प्रभेदों को ज्ञात करने हेतु उत्तम परिणाम प्राप्त हुए।

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