Study on Dehydration of Cauliflower (cv. Sereno F-1)

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Abstract
Cauliflower (cv. Sereno F-1) was collected from Babia Village Development Committee Sunsari, washed and cut into 4.2 cm x 3 cm x 1.2 cm size pieces. Effects of blanching media (plain and acidified water), pre-drying treatments (30 min dipping in 1% Potassium metabisulphite (KMS) and 1% KMS+2.5% starch solutions) and drying temperatures (55°, 65° and 75 °C in cabinet dryer) on physical, chemical and organoleptic properties of dried cauliflowers were studied. Acidified water blanching significantly improved vitamin C retention in blanched and dried samples as well as the smell of the dried sample. Vitamin C retention, rehydration ratio, color and smell did not differ significantly (p>0.05) in dried cauliflowers treated with sulfite and sulphited starch solutions, whereas non-enzymatic browning significantly increased in sulphited starch treated sample. Drying temperatures had no significant effects on rehydration and browning but vitamin C retention and sensory attributes were significantly improved (p<0.05) in 75°C dried sample. It was concluded that dehydrated cauliflower of better quality could be prepared by blanching cauliflower pieces in acidified water for 5 minutes, dipping in 1% KMS solution for 30 minutes followed by cabinet drying at 75°C to 5% moisture level.

Key words: blanching, pre-drying treatments, drying temperature

Introduction
Vegetables production plays a significant role to increase the economic status of the rural poor. Its production has substantially increased in the recent past in Nepal (Shakya 1995) and the eastern Terai and hills are contributing a lot (Karki 1995). High value crops (HVC), particularly citrus family and apple in fruits and cauliflower and tomato among vegetables, are important horticultural commodities for cash generation in both the Terai and hilly regions of Nepal. The average post harvest losses of vegetable crops within the commercial production system in the hills ranges from 20-50% (Gurung et al. 1998). The losses increase cumulatively as the produce is moved down from harvesting to the consumption. Collectively these losses lead to poor economic return to the growers ultimately affecting the consumers at large.

Sereno F-1 is one of the many hybrid cauliflower varieties often cultivated in the eastern Terai region of Nepal. It has yellowish white loosely packed curd weighing about 2 to 2.5 kg on an average. Cauliflower is a perishable commodity and has a short shelf life (less than 2 weeks even at 0°-5°C temperature and 95-100% RH). It is a popular seasonal vegetable having high consumer acceptance and nutritionally rich in major and minor nutrients and is among very few highly praised vegetables forming a substantial portion of the total production of fresh vegetables in Nepal. Being a seasonal commodity, the price of cauliflower fluctuates violently (from Rs. 4.00 to 35/kg at Dharan market, AEC 2000). During peak season, the price drops so low that it has to be sold at a throw-away price and even the harvesting and marketing costs are not recovered, thus it becomes unremunerative. On the other hand, market price starts increasing during lean periods.

There are various methods of cauliflower preservation, some of which have been commercially practiced, whereas, some others are still under study. Each commercially adapted method has its own merits and demerits. Controlled atmosphere (CA) storage, cold storage and freezing are appreciable methods regarding the retention of nutritional quality but they have limitations for they are expensive processes requiring large storage space, precise control over conditions and specialized manpower. Dehydration, undoubtedly, is an appropriate method of vegetable preservation, but there is a problem of maintaining good color, texture and rehydration characteristics. Pre-drying treatments and drying temperature need to be optimized in order to produce the dehydrated product of better quality and storability. Hence, the objective of this study was to develop an appropriate process of cauliflower dehydration in conventional electric dryer

Materials and Methods
Collection and preparation of raw materials
Fresh cauliflowers (cv. Sereno F-1) were purchased from farmer's farm at Babia Village Development Committee, Sunsari district and washed thoroughly
with water. The leaves and stalks were removed and flower heads were broken into pieces of average size of 4.2 cm x 3.0 cm x 1.2 cm.

**Optimization of blanching time and medium**
The cauliflower pieces were blanched for different time intervals in plain and acidified boiling water (water containing 0.2% citric acid) and the adequate blanching time for each of the media was found out according to Ranganna (1986). In order to find out the best blanching medium, the cauliflower pieces were separated into two lots and blanched in plain and acidified boiling water separately for pre-determined time. The blanched samples were dipped in 1% KMS solution for 30 min, drained and dried at 70°C in a cabinet dryer (Cabinet dryer model Rid/5; volts 220/440, temperature range 50-200°C) to a final moisture content of ±1%. The dried cauliflower samples were analyzed for Vitamin C contents, non-enzymatic browning, rehydration ratio and organoleptic quality (color and smell).

**Selection of pre-drying treatments and drying temperature**
Cauliflower pieces blanched in pre-optimized medium were divided into two lots. One lot was dipped in 1% potassium metabsulphite solution for 30 min. and the other was dipped in sulphited starch (2.5% corn starch in 1% KMS solution) solution for 30 min. The ratio of cauliflower pieces and the dipping medium was maintained at 1:4. The samples were drained, dried and analyzed. Likewise, cauliflower pieces, blanched and pre-treated as optimized, were dried at 55°C, 65°C and 75°C in a cabinet drier and the best drying temperature was found out.

**Analytical procedures**
**Determination of moisture content.** The moisture content was determined as per Egan et al. (1981) with slight modification. The fresh cauliflower sample was cut into small pieces, weighed and dried in hot air oven at 110 ± 3°C until a constant weight was obtained. The dried cauliflower sample was ground into powder and about 5 g of the powder was taken for moisture determination.

**Rehydration ratio.** The rehydration ratio of dried cauliflower was determined according to Ranganna (1986) with slight modification. Dried cauliflower pieces were weighed, immersed in 500 ml boiling water and taken out at an interval of 2 min. The surface water was wiped with blotting paper and the pieces were weighed to calculate the rehydration ratio.

**Estimation of vitamin C content and non-enzymatic browning.** The vitamin C content was determined by using 2,6-Dichlorophenol – Indophenol Visual Titration Method and the extent of non-enzymatic browning was determined calorimetrically (Photoelectric colorimeter Model AE – 11 Erma optical; Works. Ltd., Tokyo, Japan) as per Ranganna (1986). For non-enzymatic browning, 2 g of the dried sample was extracted with 50 ml of 60% ethanol for 12 hr and filtered. The colour of the filtrate was measured at 420 nm using 60% aqueous alcohol as blank and the absorbance was taken as a measure of non-enzymatic browning.

**Sensory evaluation.** The color and smell are important attributes in determining the quality of dried cauliflower. The dried cauliflower samples were rehydrated in plain boiling water for their respective pre-optimized times and were subjected for sensory evaluation in terms of color and smell by using 9 points hedonic rating test as per Ranganna (1986). Fifteen semi-trained panelists were asked to evaluate the preference of the samples. The responses given by them were given numerical values ranging from 9 (like extremely) to 1 (dislike extremely).

**Data analysis.** All determinations were carried out in triplicates. The experimental data were analysed by using t-test and one-way ANOVA, at 5% level of significance. The significant differences between treatment means were determined by LSD method (Gomez & Gomez 1984).

**Results and Discussion**

**Optimization of blanching time.** Cauliflower pieces were blanched in plain and acidified boiling water for different time intervals and the presence of brown colour in the aliquot was visually observed. The results of adequacy of blanching test are given in Table 1. The brown colour was observed up to four min blanching in both media and samples blanched for ≥ five min showed negative peroxidase test indicating that five min blanching was adequate in either medium.

| Table 1. Effect of blanching time on the inactivation of peroxidase enzyme
<table>
<thead>
<tr>
<th>Blanching time (min.)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<tbody>
<tr>
<td>Color reaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PW*</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Replicate 1</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Replicate 2</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Replicate 3</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CA**</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Replicate 1</td>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Replicate 2</td>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Replicate 3</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

¹Enzyme activity expressed in terms of presence (+) or absence (-) of brown color
* PW: Cauliflower pieces blanched in plain water
** CA: Cauliflower pieces blanched in acidified (0.2% citric acid) water
Table 2. Effect of blanching media on physicochemical characteristics of cauliflower

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Un-blanched</th>
<th>Plain water blanched</th>
<th>Acidified water blanched</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin C content (mg/100g d.m.)</td>
<td>851.39 (7.57)</td>
<td>436.04 (4.82)</td>
<td>504.28 (5.29)</td>
</tr>
<tr>
<td>%Vitamin C retention1 before drying</td>
<td>51.2a (0.57)</td>
<td>59.2b (0.62)</td>
<td></td>
</tr>
<tr>
<td>%Vitamin C retention after drying</td>
<td>35.46a (0.47)</td>
<td>42.43b (0.74)</td>
<td></td>
</tr>
<tr>
<td>Browning index (O.D.)</td>
<td>0.045a (0.00)</td>
<td>0.042a (0.003)</td>
<td></td>
</tr>
<tr>
<td>Rehydration ratio</td>
<td>10.24:1a (0.34)</td>
<td>11.46:1a (1.04)</td>
<td></td>
</tr>
</tbody>
</table>

1Vit. C retention based on the Vitamin C content of the fresh sample.
*Values are the means of three determinations. Means followed by the
**same latter in a row do not differ significantly at 5% level.
†Figures in parentheses are the standard deviations.

Analogous result was also reported by Kaur and Singh (1981). Shrivastava and Nath (1984) reported slightly longer blanching time (six min) in boiling water while Srivastava and Sulebele (1975) found a bit shorter blanching time (four min) in hot water. These variations in blanching time may be due to the differences in cauliflower variety, size of cauliflower pieces and the ratio of the pieces to the blanching medium.

Effects of blanching media on the quality of cauliflower: The vitamin C contents in fresh, blanched and dried samples, and extent of non-enzymatic browning, and rehydration property of the dried cauliflower were analyzed and the results are shown in Table 2. The vitamin C contents (mg/100g d.m.) in unblanched, plain and acidified boiling water blanched samples were 851.39, 436.04 and 504.28 respectively. Vitamin C retentions of 51.2% and 35.46% were found in plain water blanched and dried samples respectively. Similarly the values for acidified water blanched and dried samples were 59.22% and 42.43% respectively. Statistically, the Vitamin C retentions in acidified water blanched and dried samples were significantly higher (p<0.05) over the control (plain water blanched and dried samples). Woyke and Szaniawska (1969) reported a higher amount of Vitamin C retention (84.5%). However, both the authors did not mention blanching time, temperature and variety of cauliflower used in the study, which could have attributed to the variation in the result.

The extents of non-enzymatic browning (expressed in terms of optical density) of dried samples were found to be 0.045 and 0.042 for plain and acidified water-blanched samples respectively (Table 2). However, the effect of acidified water blanching on non-enzymatic browning was not significant (p>0.05). Blanching cauliflower pieces in a solution of chelating agent (0.25% EDTA +1% citric acid) was tried by Shrivastava and Nath (1984) but they did not find any significant improvement in colour of the dried product.

The rehydration ratios were found to be 10.24:1 and 11.46:1 for plain and acidified water blanched and dehydrated samples respectively (Table 2). But, acidified water blanching did not improve the rehydration property significantly (p>0.05) over plain water blanching (control). A negative effect on the rehydration of dried cauliflower blanched in a solution of chelating agents (0.25% EDTA + 1% citric acid) was reported by Shrivastava and Nath (1984).

Sensory evaluation of dried samples was carried out for color and smell and the mean scores are shown in Fig. 1. The average scores for color and smell were 7.26, 6.86 and 5.66, 7.2 for dried samples blanched in plain and acidified boiling water respectively. The color of the both samples was liked moderately whereas the smell of dried samples blanched in plain and acidified water were liked slightly and liked very much respectively by the panelists. However, statistical test did not indicate any significant difference in color but there was a significant difference (p<0.05) in smell of the two samples. Hence, blanching in acidified boiling water for five minutes was considered to be optimum.

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![Fig. 1. Effect of blanching media on color and smell of dried cauliflower.](image)
Effects of pre-drying treatments on the quality of dried cauliflower. Effects of sulphite and sulphited-starch pre-treatment on Vitamin C retention, non-enzymatic browning and rehydration property of the dried cauliflower are shown in Table 3. Statistical test showed that incorporation of starch in sulphite solution had no significant effect on Vitamin C retention in dried product. Agrawal (1998) reported a higher difference in Vitamin C retention (40%) of dried samples pre-treated in sulphite (0.75%NaMS +0.25% NaS) and sulphited starch (sulphite +2.5% starch) solutions for 30 min. The variation in the results could be due to the difference in type and strength of SO₂ generating compounds and variety of cauliflower used.

Sulphited starch dipped and dried sample showed significantly higher (p<0.05) degree of browning than that of sulphite treated sample. Srivastava and Nath (1984) found an opposite result to that of our experiments, when they dipped cauliflower pieces in sulphited starch (0.75% Sodium metabisulphite+ 0.25% sodium sulphite + 2.5% starch) solution for 15 min. This contradiction could be due to the variation in dipping time, dipping solution, blanching medium and variety of cauliflower used. The dried sample pre-treated with sulphited starch showed higher rehydration ratio (13.32:1) over the control (12.43:1) (Table 3), but the values were not significantly different (p>0.05).

Table 3. Effects of pre-drying treatments on the quality of dried cauliflower

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Pre-drying treatments</th>
<th>Sulphite (1%KMS)</th>
<th>Sulphited starch solution (1%KMS+2.5% starch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vit. C retention (%)</td>
<td>70.75±(2.87)</td>
<td>71.17±(1.95)</td>
<td></td>
</tr>
<tr>
<td>Browning index (0.D.)</td>
<td>0.045±(0.00)</td>
<td>0.057±(0.003)</td>
<td></td>
</tr>
<tr>
<td>Rehydration ratio</td>
<td>12.43:1(0.72)</td>
<td>13.32±1(0.67)</td>
<td></td>
</tr>
</tbody>
</table>

*Vitamin C retention based on the vit. C content of blanched sample before drying.

The dried samples were evaluated for color and smell and the mean scores are shown in Figure 2. The color and smell of both samples were liked slightly and moderately by the panelists. Statistical tests indicated no significant differences in color and smell of the two samples.

Effects of drying temperature on the quality of dried cauliflower. Table 4 gives the effect of drying temperature on Vitamin C retention, non-enzymatic browning and rehydration characteristic of the dehydrated cauliflower. Vitamin C retention in samples dried at 55°C, 65°C and 75°C were found to be 73.03%, 59.66% and 70.9% respectively.

![Figure 2](image)

Fig. 2. Effect of pre-drying treatments on color and smell of dried cauliflower.

Statistical analysis showed that the temperature had a significant effect (p<0.05) on Vitamin C retention. LSD indicated that the Vitamin C retention of the samples dried at 65°C was significantly lower (p<0.05) than samples dried at 55°C and 75°C but the difference between the latter two was insignificant.

Table 4. Effects of drying temperature on physicochemical characteristics of dried cauliflower

<table>
<thead>
<tr>
<th>Parameters</th>
<th>55°C</th>
<th>65°C</th>
<th>75°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin-C retention (%)</td>
<td>73.0±(2.87)</td>
<td>59.66±(2.32)</td>
<td>70.9±(14.82)</td>
</tr>
<tr>
<td>Browning index (0.D.)</td>
<td>0.045±(0.00)</td>
<td>0.057±(0.003)</td>
<td>0.02±(0.006)</td>
</tr>
<tr>
<td>Rehydration ratio</td>
<td>12.43±1(0.72)</td>
<td>13.32±1(0.67)</td>
<td></td>
</tr>
</tbody>
</table>

*Vitamin C retention based on the vit. C content of the sample before drying.

Values are the means of three determinations. Means followed by the same letter do not differ significantly at 5% level.

Figures in parentheses are the standard deviations.

Desrosier and Desrosier (1987) reported a better Vitamin C retention in rapid drying at higher temperature than in slow drying at lower temperature. The poor retention of Vitamin C in sample dried at 65°C may be due to the fact that Vitamin C loss depends not only on drying temperature but also on drying time. At 65°C a combined effect of both drying time and temperature may have caused higher loss of Vitamin C. The extent of non-enzymatic browning and rehydration ratio of the dried samples were not significantly affected by drying temperature.

The samples dried at different temperatures were evaluated for color and smell. The mean sensory scores are depicted in Fig. 3. The color of the samples dried at 75°C and 65°C was liked moderately but that of the sample dried at 55°C was neither liked nor disliked by
the panelists. In terms of smell, the samples dried at 75°C, 65°C and 55°C were evaluated as liked moderately liked slightly and neither liked nor disliked respectively. Statistical test indicated that the samples were significantly different (p<0.05) in terms of both color and smell.

Fig. 3. Mean sensory scores of cauliflower dried at different temperature.

LSD showed that samples dried at 75°C and 65°C were significantly different in color and smell than that dried at 55°C but the difference between the former two was insignificant.

Blanching cauliflower pieces in acidified (0.2% citric acid) boiling water for 5 minutes was found to be optimum for enzyme inactivation; controlling non-enzymatic browning; better Vitamin C retention, rehydration property, color and smell of the dried cauliflower. Blanched cauliflower pieces when dipped in 1% KMS solution for 30 min and dried at 75°C in a cabinet drier resulted better product quality. Commercialization of dehydrated cauliflower seems promising provided suitable packaging material is used.

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References


