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Study on dehydration of cauliflower (*Brassica oleracea* var. botrytis)

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Abstract
The present study was carried out to study different pre-treatments, optimum drying time and temperature of cauliflower and rehydration of dried cauliflower. The sample cauliflower was prepared by soaking the blanched pieces in solution of different concentrations of salt and sucrose prior to drying. The samples of 250 gm for each treatment were dried in tray dryer at drying temperature 50^0C. It was observed that the moisture content decreased with the drying time. The time required for samples of respective treatment to reduce moisture from 1308.45%(db) to 11.04%(db), 10.54%(db), 8.98%(db), 11.92%(db), 11.13%(db), 10.73%(db), 14.08%(db), 11.93%(db) and 12.75%(db) respectively was 10-12hrs. Similarly, for quarter cut the time required for dehydration was about 11.5 hrs to 17.5 hrs. It is evident from these results that the drying was faster for pieces followed by quarter at 50ºC temperature. The treatment of 5%NaCl+0.1%KMS gave minimum time of 10 hrs with drying temperature of 50^0C.The maximum rehydration ratio was 5.7 for the treatment of 5%Sucrose+ 5%NaCl+0.1% KMS with drying temperature of 50^0C.
The optimum treatment was soaking in 5% Sucrose + 5%NaCl + 0.1%KMS for 1 hr. at room temperature and drying in a tray dryer at 50^0C.

Keywords: KMS - potassium metabisulphite, NaCl- sodium chloride, db- dry basis, wb-wet basis, hr-hour, wt-weight and mg- milligram

Introduction
Cauliflower is a cole crop belonging to family cruciferae and botanical name is *Brassica olaracea* var. botrytis. Cauliflower was introduced in India in 1822 (Lund D.B *et.al.*1972). The initial introduction was of the Cornish types from England and later the other European types were also introduced. The typical Indian cauliflowers were the result of intercrossing between the Cornish and the other European types. World production of cauliflower is 13.5 million tonnes. Although India is the highest producer of cauliflower, its productivity is lower than average (Mudgal V.D., and Pandey V.K., 2008) [13].
Major states producing cauliflower are Bihar, Uttar Pradesh, Orissa, West Bengal, Assam, Haryana and Maharashtra. Out of total of 53, 35,447 ha of land under vegetables cauliflower occupy 4.12% area. From a total area of 2, 20,025 ha under cauliflower in India the production was 24, 73,987 mt during the year 1995-96 having 3.46% share in the total vegetable production.
Cauliflower is a rich source of vitamin B. The edible portion of cauliflower is 45%. The composition of cauliflower per 100gm edible portion is as follows:
Moisture (%): 89.4-92.7, Protein (%): 0.37-2.7, Fat (%): Trace-0.40, Minerals: 1.4, Ca (mg/100gm): 21-25, K (mg/100gm): 295-350, P (mg/100gm): 95-56, Carbohydrates (%): 5.2, Vittamins-Carotene (µg/100gm): 6-50, Ascorbic acid(mg/100gm): 50-90, Vitamin B6(mg/100gm): 0.2, Folic acid(µg/100gm): 39, Pantothenic acid(mg/100gm): 0.6, Biotin(mg/100gm): 1.5.
Cauliflower is a popular and highly priced winter vegetable, perishable in fresh condition. Considerable wastage of cauliflower occurs due to spoilage. The major portion of the cauliflower is consumed fresh, only limited quantity is processed, mostly in canned and dehydrated forms. Canned cauliflower is bulky, heavy and has problem of disintegration and discoloration. (Setty and Ranganna, 1972) [20] At present, there is no suitable technology which can be given to farmers for processing of their produce in harvesting season and selling the same at reasonable price in off season. Generally, time of harvesting of hot weather cauliflower and cold weather cauliflower is September to December and January to February

respectively. Ordinarily cauliflower may be stored in open for 2-3 days in winter but it is difficult to store as such in summer. However good or sound heads can be stored in cold storage for about a month at 0˚C with 85% and 95% RH (Chauhan, D.V.S., 1992) [5]. For refrigeration storage of cauliflower, temperature range is in between 0 to 2˚C and approximate storage life is 7 weeks. In canned preservation of cauliflower a) type of can used is plain; b) strength of brine used is 2% common salt with processing time at 0.7 kg/m^2 steam pressure is 20 to 30 min. The can is exhausted at 89˚ to 100˚C for 7 to 10 min. (Girdharilal and Siddhapa, 1986) [6].
Dehydration of crop could be an alternative to lengthen the life of cauliflower when dried by conventional drying method yields a product with poor texture, color, flavor and rehydration characteristics, further several shrinkage and diffusion of solutes which occur during slow drying process prevent rapid and full rehydration and the product becomes tough and leathery even after cooking. (Shah M. R., Patil N. D. and Kadam R. R., 1996) [21]. Attempts are made by several workers to minimize the shrinkage and improve rehydration of dehydrated vegetables by vacuum puffing and high temperature short time pneumatic drying. The pretreatments to cauliflower with glucose were also reported to give a product with higher coefficient of rehydration. The present research work was undertaken to study the dehydration of cauliflower to standardize suitable pretreatments prior to dehydration and work out dehydration and rehydration characteristics of cauliflower.

Material and Method
The present research work on Dehydration of cauliflower in tray dryer was carried out at Department of Agricultural Process Engineering, Faculty of Agricultural Engineering, MPKV, Rahuri. The vegetable cauliflower, were procured from Krishi Utpanna Bazaar Samitee, Rahuri. The variety of cauliflower taken for the study was Snowball-16.

Sample Preparation
Fresh fully matured white and compact cauliflower heads were selected for the experiment. The leaves were removed and heads were thoroughly washed, trimmed to remove hard main stem and cut into pieces of 2-3 cm length and 1-2cm width.

Blanching
Hot water blanching method was used. The samples were blanched in boiling water at 98ºC for 5 min. The gas stove was used to boil the water and the temperature was maintained. Each time 250gm of sample was taken into muslin cloth and dipped into boiling water for 5 min.

Treatments
The cut cauliflower (pieces and quarter) after blanching were given different pretreatments. The sample of 2.25kg was taken for pretreatment.

Treatment with 2.5% NaCl solution
The samples were blanched and then drained for 1 hr. and cooled and then soaked in 2.5% common salt solution along with 0.1% KMS for 1 hr. at room temperature. After 1 hr. the sample was taken out of solution and drained.

Treatment with 5% NaCl solution
The solution of 5% NaCl+0.1% KMS concentration was prepared. The blanched sample after being drained and cooled, dipped in 5% common salt solution for 1 hr. After treatment the sample was drained.

Treatment with 7.5% NaCl solution
The solution of 7.5% NaCl+0.1% KMS concentration was prepared. The blanched sample after being drained and cooled, dipped in 7.5% common salt solution for 1 hr. After treatment the sample was drained.

Treatment with 2.5% Sucrose+2.5% NaCl solution
The solution of 2.5%Sucrose+2.5% NaCl+0.1% KMS concentration was prepared. The blanched sample after being drained and cooled, dipped in solution for 1 hr. After treatment the sample was drained.

Treatment with 2.5%Sucrose+5% NaCl solution
The solution of 2.5%Sucrose+5% NaCl+0.1% KMS concentration was prepared. The blanched sample after being drained and cooled, dipped in solution for 1 hr. After treatment the sample was drained.

Treatment with 2.5%Sucrose+7.5% NaCl solution
The solution of 2.5%Sucrose+7.5% NaCl+0.1% KMS concentration was prepared. The blanched sample after being drained and cooled, dipped in solution for 1 hr. After treatment the sample was drained.

Treatment with 5%Sucrose+2.5% NaCl solution
The solution of 5% Sucrose+2.5%NaCl+0.1% KMS concentration was prepared. The blanched sample after being drained and cooled, dipped in solution for 1 hr. After treatment the sample was drained.

Treatment with 5%Sucrose+5% NaCl solution
The solution of 5%Sucrose+5% NaCl+0.1% KMS concentration was prepared. The blanched sample after being drained and cooled, dipped in solution for 1 hr. After treatment the sample was drained.

Treatment with 5%Sucrose+7.5% NaCl solution
The solution of 5%Sucrose+7.5% NaCl+0.1% KMS concentration was prepared. The blanched sample after being drained and cooled, dipped in solution for 1 hr. After treatment the sample was drained. The moisture content of cauliflower was determined on dry basis (db). The standard oven method was used for moisture content determination. The sample of 15gm was taken for the experiment. This sample was kept in an electric hot oven at 103ºC for 17 hr. until the material was bone dry (Anon). The moisture content was determined by the following formula (Hall C. W 1957) [7].

$$\text{Moisture Content (db)} = \frac{(W_1 - W_2)}{W_2} \times 100$$

$$\text{Moisture Content (wb)} = \frac{(W_1 - W_2)}{W_1} \times 100$$

Where, W_1 = Weight of wet sample, gm
W_2 = Weight of bone dry material, gm

Dehydration
The cauliflower soaked, as above to infuse the additives, were drained thoroughly, and spread on aluminium tray 500mm×500mm×35mm. The sample taken for dehydration was 250gm. The thickness of spread of sample was 2cm on

tray. The samples were dried in tray type dryer. The temperature for drying was taken as 50ºC. During dehydration process, the moisture contents were recorded for an interval of half hour to two hours till final moisture content was reduced to 8-12 % (db).

Drying Rate

Drying rate expressed as gm of water per hour per 100gm bone dry material and was calculated as follows (Chakraverty and De, 1981) [3]:

$$\text{Drying Rate} = \frac{\text{Amount of moisture removed (gm)} \times 100}{\text{Time taken (hr.)} \times \text{Total bone dry wt. of sample (gm)}}$$

The total time required for dehydration of cauliflower was recorded.

Rehydration

To compare the dried sample of various treatments, cauliflower pieces were rehydrated by adding 200ml boiling water to 10gm material in a beaker, allowed to steep, covered for 20 min., drained for 1 min. and then weighed.

Rehydration ratio was calculated from the following relationship (Indian Standards Institute, 1963)

$$\text{Rehydration Ratio} = \frac{\text{Wt. of reconstituted dehydrated cauliflower sampl}}{\text{Wt. of dehydrated cauliflower sample}}$$

Results and Discussion

To conduct the experiment on dehydration of cauliflower, the sample was blanched in boiling water for 5 min. and then samples was treated with,

a) 2.5%NaCl + 0.1%KMS,
b) 5%NaCl+0.1%KMS,
c) 7.5%NaCl+0.1%KMS,
d) 2.5%Sucrose+2.5%NaCl + 0.1%KMS,
e) 2.5%Sucrose+5%NaCl+0.1%KMS,
f) 2.5Sucrose+%2.5%NaCl+ 0.1%KMS,
g) 5%Sucrose + 2.5%NaCl + 0.1%KMS,
h) 5%Sucrose+5%NaCl+0.1%KMS,
i) 5%Sucrose+7.5%NaCl+0.1%KMS.

Before drying of treated sample initial moisture content was determined. Then the samples were dried at 50ºC temperature in tray type dryer.

Moisture content vs. drying time

It was observed that the moisture content decreased with the drying time. The sample of 250gm (pieces), each of treatment mentioned above was dried at 50ºC in tray dryer. The time required for samples of respective treatment to reduce moisture from 1308.45%(db) to 11.04%(db), 10.54%(db), 8.98%(db), 11.92%(db), 11.13%(db), 10.73%(db), 14.08%(db), 11.93%(db) and 12.75%(db) respectively was 10-12hrs.

Similarly, for quarter cut the time required for dehydration was about 11.5hrs to 17.5hrs. It is evident from these results that the drying was faster for pieces followed by quarter at 50ºC temperature.

Drying rate vs. drying time

Drying rate decreased with drying time for pieces and quarter cut at 50ºC temperature. It was observed that drying rate was higher for pieces followed by quarter cut.

Discussion

It was observed that maximum time required for dehydration was 17.5hrs for 5%Sucrose+5%NaCl+0.1%KMS treatment for quarter cut.

Similarly, the minimum time required for dehydration was 10hrs for 2.5%NaCl+0.1%KMS and 5%NaCl+0.1%KMS treatment for pieces.

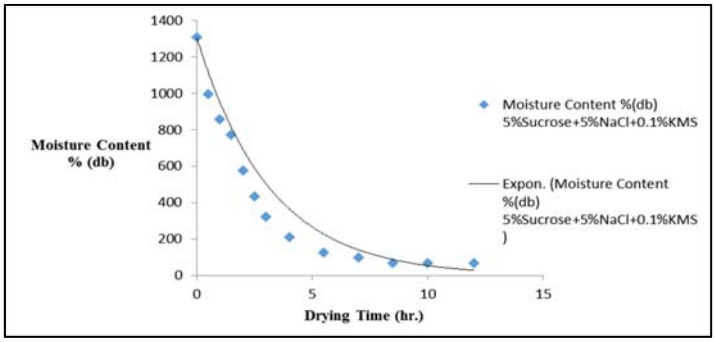

Fig 1: Graph of Drying Time vs. Moisture Content (5%Sucrose+5%NaCl+0.1%KMS) at 50^{0}C

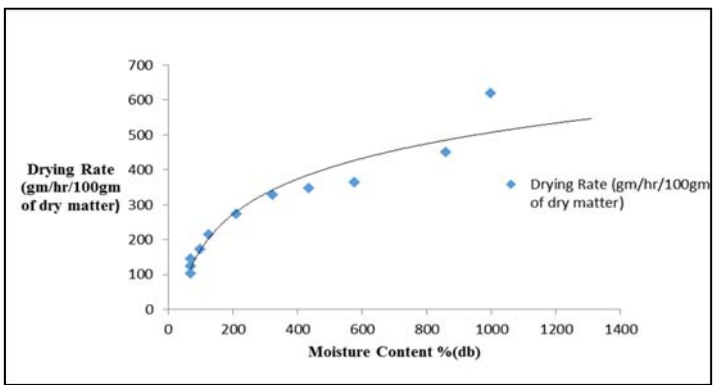

Fig 2: Graph of Moisture Content vs. Drying (5%Sucrose+5%NaCl+0.1KMS) at 50

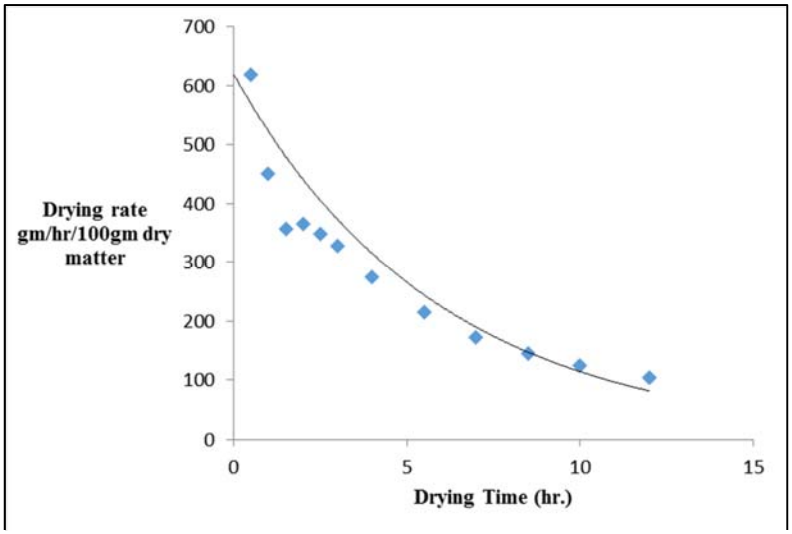

Fig 3: Drying Curve for Drying Time vs. Drying Rate (5%Sucrose+5%NaCl+0.1KMS) at 50^{0}C

Dehydration Test

The maximum dehydration ratio observed was 12.95 for pieces treated with 2.5%NaCl+0.1%KMS and 14 for quarter cut treated with 2.5%NaCl+0.1%KMS.

The minimum dehydration ratio observed was 6.67 for pieces treated with 5%Sucrose+7.5%NaCl+0.1%KMS and 6.0 for quarter cut treated with 5%Sucrose+7.5%NaCl+0.1%KMS.

Rehydration Test

The Maximum rehydration ratio observed was 5.7 for pieces treated with 5%Sucrose+5%Nacl+0.1%KMS and 4.8 for quarter cut treated with 5%Sucrose+5%Nacl+0.1%KMS.

The minimum rehydration ratio observed was 3.1 for pieces treated with 2.5%Sucrose+7.5%NaCl+0.1%KMS and 3.0 for quarter cut treated with 5%Sucrose+7.5%NaCl+0.1%KMS.

Among above nine treatments the treatment of 5% Sucrose+5%Nacl+0.1%KMS gives best results.

Table 1: Influence of drying period on moisture content and drying rate, Sample: Pieces, Temperature: 50ºCTreatment: .5%Sucrose+5%NaCl+0.1KMS

Drying Time (hr.)	Moisture Content %(db)	Drying Rate (gm/hr/100gm dry matter)
0.0	1308.45	-
0.5	1054.73	507.04
1.0	914.19	394.36
1.5	829.36	319.24
2.0	632.60	338.02
2.5	463.38	338.02
3.0	350.65	319.24
4.0	209.88	274.64
5.0	125.37	236.62
6.5	97.19	186.34
8.0	69.03	154.92
10.0	69.03	123.94
12.0	69.03	103.28

Table 2: Dehydration ratio for different treatments at 50º

Treatment	Dehydration Ratio	
	Pieces	Quarter
2.5%NaCl+0.1%KMS	12.95	14.00
5%NaCl+0.1%KMS	10.4	12.00
7.5%NaCl+0.1%KMS	8.33	9.50
2.5%Sucrose+2.5%NaCl+0.1%KMS	10.4	7.33
2.5%Sucrose+5%NaCl+0.1%KMS	8.33	13.00
2.5%Sucrose+7.5%NaCl+0.1%KMS	8.33	9.00
5%Sucrose+2.5%NaCl+0.1%KMS	8.56	11.00
5%Sucrose+5%NaCl+0.1%KMS	8.30	9.00
5%Sucrose+7.5%NaCl+0.1%KMS	6.67	6.00

Table 3: Rehydration ratio for different treatments at 50 °C

Treatment	Rehydration Ratio	
	Pieces	Quarter
2.5%NaCl+0.1%KMS	4.3	4.0
5%NaCl+0.1%KMS	3.4	3.5
7.5%NaCl+0.1%KMS	3.2	3.0
2.5%Sucrose+2.5%NaCl+0.1%KMS	4.2	4.5
2.5%Sucrose+5%NaCl+0.1%KMS	3.5	3.4
2.5%Sucrose+7.5%NaCl+0.1%KMS	3.1	3.3
5%Sucrose+2.5%NaCl+0.1%KMS	4.2	3.6
5%Sucrose+5%NaCl+0.1%KMS	5.7	4.8
5%Sucrose+7.5%NaCl+0.1%KMS	4.1	3.0

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