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Dehydration of math by different drying methods

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ABSTRACT : Vegetables are highly perishable commodities and, therefore, need to be preserve as long as possible in order to make the commodity available in off seasons. Dehydration is a value addition operation of a produce. The optimization of such an operation leads to an improvement in the quality of the output. Dehydrated vegetables are used basically as a raw material in food products. In the present investigation, dehydration of math (*Amaranthus cruentus)* was carried out by tray drying and microwave drying. Before going for dehydration test physical properties of math (*Amaranthus cruentus)* were determined. The temperatures selected for tray drying were 40^0C, 50^0C and 60^0C. The math (*Amaranthus cruentus)* was also dried in microwave oven for three different durations *i.e.*10 sec, 1 min and 2 min. The dehydrated math (*Amaranthus cruentus)* was tested for ascorbic acid content, â-carotene content, rehydration test and organoleptic evaluation.

KEY WORDS : Math, Dehydration, Rehydration, Tray drying, Microwave drying

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India is the largest producer of vegetable in the world next only to China with an annual production of 72.83 million tonnes from 5.63 million ha with an average productivity of 13t/ha (Lidhco, 2006). Though the vegetable requirement is 300g/day/person as recommended by dietician, we are able to meet about 1/9th of that requirement only (Anonymous, 2008).The green leafy vegetables are a group of edible leaves that are rich in nutrients such as vitamins and minerals. Some of the vegetables, which fall in this group, are spinach, amaranth, drumstick leaves, fenugreek leaves, mustard leaves, mint, and coriander. The green leafy vegetables are rich source of calcium, iron, beta-carotene, vitamin C, riboflavin, and folic acid. They contain all major nutrients required for growth and maintenance of health. The iron requirements of the body can be met to a considerable extent if green leafy vegetables are consumed daily in the diet. Vitamin C present in green leafy vegetable helps to absorb iron more efficiently. The dietary fibers supplied by leafy vegetables are useful for good bowl movement. At least 50 g of these inexpensive vegetables is recommended daily (Anonymous, 2008). The recommended dietary allowance of green leafy vegetables for an adult woman is 100g/day, adult man 40g/day, preschool children (4-6 yrs) 50g/day and for boys and girls beyond 10 yrs of age it is 50g/day (Anonymous, 2008).

Konkan region of Maharashtra is located in Western Ghats of the country and topography is such that supply of vegetables to the region form other part is cumbersome and expensive. Region produces most of the vegetables to meet the demand. Math (*Amaranthus cruentus*) or Rajgira is very popular in the region and people of the region love to have it round the year. However, being perishable in nature and also seasonal cannot be made available throughout the year.

However, traditional market places with their long established methods of buying and selling vegetables are faced with new problems, which are likely to produce many changes in the general pattern of marketing. Vegetables are highly seasonal and are usually available in plenty at a particular part of the year .In the peak season; the selling price becomes too low leading to heavy losses to the grower. Also, due to the abundant supply during the season, there is a glut in the market resulting in the spoilage of large quantities. Preservation of these vegetables can prevent the huge wastage and make them available in the off-season at remunerative prices.

Dehydrated vegetables can be produced by a variety of processes. These processes differ primarily by the type of drying method used, which depend on the type of material to be dehydrated and the type of characteristics desired in the end product. In general, the process of dehydration of fruits and vegetables involves pre-drying treatments, such as size selection, peeling and colour preservation, drying or dehydration, using natural or artificial methods and post-

dehydration treatments, such as sweating, inspection and packaging.

In order to make available math or rajgira in lean season, preservation is essential. Sun drying is traditional method of preservation of math or Rajgira. But sun dried product is of poor quality especially with regards to colour and flavour by the direct exposure to sun as often practiced (Jayaraman *et al.*, 1991). Also, Sun drying is not hygienic, does not have a control over drying and is not dependable throughout the year.

METHODOLOGY

This chapter deals with experimental set up, material used and the methodology adopted for study. The proposed research work on "dehydration of math by different drying methods" was carried out in the Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli.

Material and equipments used in study :

Material and equipments used in present investigation are given as below:

Math (Amaranthus cruentus) :

Fresh math (*Amaranthus cruentus*), procured from local market was used for the research work.

Tray dryer :

Tray dryer (M/s. Rotex Industries, Pune) available in the Department of Agricultural Process Engineering was used for the dehydration studies. Temperature of the dryer was set at predetermined temperature and experiments were performed. The numbers of trays present in the dryer are 24. The size of each tray is 50 cm x 50 cm.

Microwave oven :

Microwave oven was used for drying. The oven was manufactured by M/s. LG Electronics India Pvt. Ltd.

Weighing balance :

The Contech make weighing balance with accuracy 1 g was used for measuring the weight of the trays during drying.

Digital temperature and RH meter :

This was used for the measurement of relative humidity in percentage and temperature of drying and ambient air.

Colour flex meter :

The Hunter Lab., USA make colour flex meter was used for colour analysis of math.

Digital bomb calorimeter :

The Parr, USA make digital bomb calorimeter was used to determine the energy value of math.

Microwave vacuum dryer :

Microwave vacuum dryer available with the National Agricultural Innovative Project laboratory of the College of Agricultural Engineering and Technology, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli (M.S.) was used for the drying of math (*Amaranthus cruentus).* The dryer is manufactured by M/s. S.B. Panchal and Company, Mumbai. In Microwave vacuum drying the heat is generated by directly transforming the electromagnetic energy into kinetic molecular energy, thus the heat is generated deep within the material to be dried.

Methodology :

This section consists of procedures/methodology for studying the changed characteristics of math (*Amaranthus cruentus) i.e.* moisture content after tray drying, microwave oven drying, rehydration ratio, ascorbic acid content. These are described briefly and presented in the following sub section.

Dehydration of leafy vegetables requires drying equipment. The study of dehydration of math (*Amaranthus cruentus*) was conducted using two drying methods *viz.,* Tray drying and Microwave oven drying.

Sample preparation :

- The fresh, matured math (*Amaranthus cruentus*) was procured from local market.
- The Math was washed with water to remove the soil particles, surface dried and stems was removed.
- It was destalked.
- After that it was used for dehydration.

Treatments involved in experiment :

Treatments involved in experiment are given in Table A.

Table A : Treatments involved in experiment

Sr. No.	Treatments	Particulars
1.	T_1	Tray drying at 40^0C
2.	T_2	Tray drying at 50^0C
3.	T_3	Tray drying at 60^0C
4.	T_4	Microwave oven drying at 10sec.
5.	T_5	Microwave oven drying at 1min.
6.	T_6	Microwave oven drying at 2min.

Determination of moisture content :

The moisture content of math was determined using by oven dry method. The 10 g of sample was taken and kept in the oven at 103^0C for 17 h.

Moisture content (% w. b.) was determined by the following formula :

$$\text{Moisture content (\% w.b.)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \text{x100} \quad \text{....(1)}$$

Dehydration of math (*Amaranthus cruentus*) :

Mechanical drying (Tray drying) :

Tray dryer (Rotex make) available in the Department of Agricultural Process Engineering was used for the dehydration of math (*Amaranthus cruentus*) at temperatures of 40, 50 and 60^{0}C. The numbers of trays available in the dryer are 24. The size of each tray is 50 x 50cm.

Clean math leaves were spread on aluminum trays (30 g/ tray). Then trays were kept for dehydration in tray dryer at temperatures of 40^{0}C, 50^{0}C, and 60^{0}C. At every 30 min. intervals weights of tray were taken. Readings were taken till constant readings obtained.

Microwave oven drying :

Microwave oven available with the NAIP lab of the CAET, Dapoli was used for the drying of math (*Amaranthus cruentus*). The oven was manufactured by M/s. LG Electronics India Pvt. Ltd. In microwave oven microwaves are short length, high frequency electromagnetic waves. In a microwave oven, a vacuum tube called "Magnetron" generates these microwaves which directly penetrate by the food and agitate the moisture molecules present in the food.

Clean math leaves of 50g were spread on non-stick *tawa*. Then non-stick *tawa* kept for dehydration in microwave oven at the duration of 10 sec., 1 min., and 2 min. At every 10 sec. interval take reading for 10sec. treatment, at every 1min. interval take reading for 1min. treatment and at every 2min. interval take reading for 2min. treatment till constant weight was obtained.

Colour analysis :

The colour of the sample *i.e.* math were analyzed by using colorimeter (model, COLORFLEX, Hunter Lab. Associates, USA). The colorimeter was calibrated each time against standard white plate. For each sample at least five readings were taken. Three Hunter parameters namely, L (lightness), a (redness/greenness), b (yellowness/blueness) and yellowness index were measured.

Rehydration test :

Rehydration test is necessary to visualize changes occurring during dehydration process. In rehydration test, two to five gram sample of dried material is taken. It is soaked in hot water with a little lemon juice for 15 minutes, and thereafter water is drained out well. Take weight of sample after soaking and gain of water was calculated.

Rehydration ratio can be determined by following formula:

$$\text{Rehydration ratio} = \frac{\text{Weight of rehydrated sample}}{\text{Weight of dehydrated sample used for test}} \quad \text{....(2)}$$

Quality evaluation of dehydrated product :

Ascorbic acid test :

Ascorbic acid content of dehydrated math was determined by using standard method formula:

$$\text{Ascorbic acid content (mg/100 g)} = \frac{\text{Titre} \times \text{dye factor} \times \text{vol. made up} \times 100}{\text{Aliquot of extract taken} \times \text{wt. of sample taken}} \quad \text{....(3)}$$

Sensory evaluation :

The sensory evaluation of different organoleptic properties of dehydrated math leaves for colour, flavour and taste was carried out by panel of nine judges of different age group and sex on the basis of '9' point Hedonic scale. The overall acceptability of the product was taken as the average score of all these organoleptic properties.

■ RESULTS AND DISCUSSION

Dehydration of math was done by mechanical drying (tray drying) and microwave oven drying.

Dehydration of math :

The data of effect of dehydration time on removal of moisture content for all the treatments is shown in Fig.1. The drying curves are plotted as moisture content Vs dehydration time) and rate of dehydration Vs dehydration time.

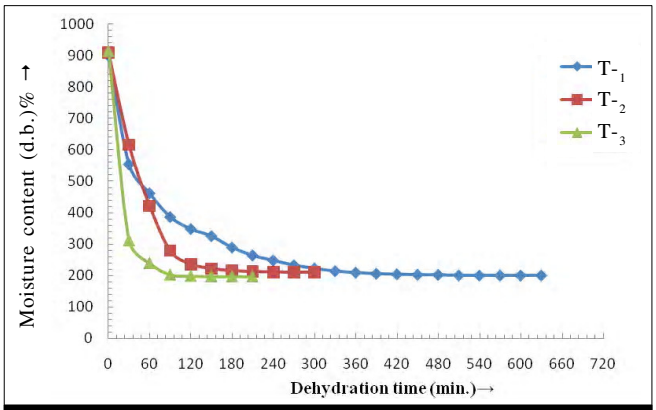

Fig 1: Effect of dehydration time on moisture content (tray drying)

Effect of dehydration time on moisture content for tray drying:

The effect of dehydration time on moisture content for tray drying is plotted and shown in Fig 1. The moisture content

decreased with dehydration time non-linearly upto bone dry weight for all the treatment.

Effect of dehydration time on moisture content for microwave oven drying :

The effect of dehydration time on moisture content for microwave oven drying is plotted and shown in Fig. 2 to 4. The moisture content decreased with dehydration time non-linearly up to bone dry weight for all the treatment.

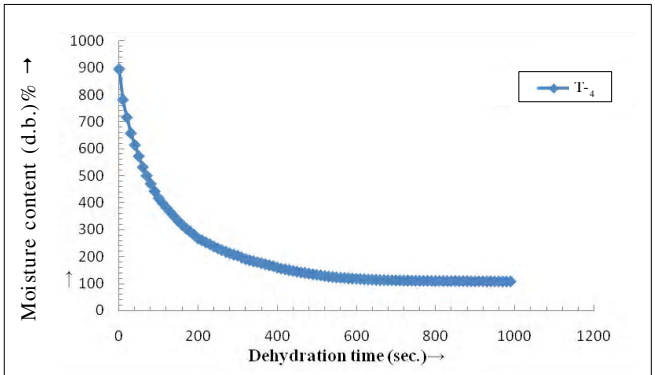

Fig 2: Effect of dehydration time on moisture content at duration of 10 sec.

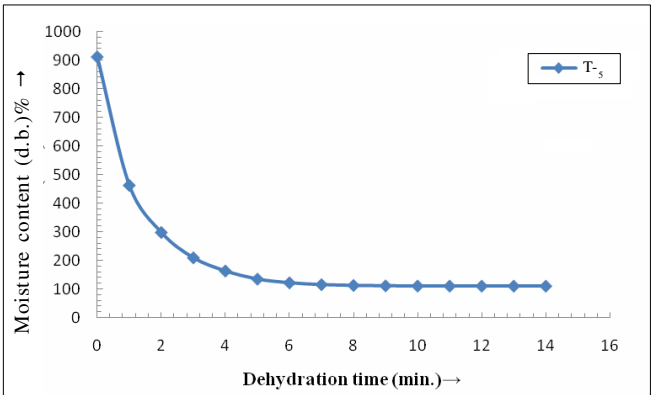

Fig 3: Effect of dehydration time on moisture content at duration of 1min.

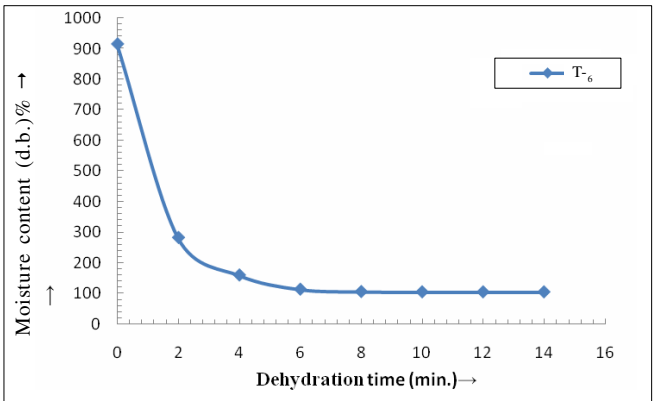

Fig 4: Effect of dehydration time on moisture content at duration of 2min.

As temperature and duration increases, dehydration time decreases in case of tray drying and microwave oven drying. The total time required for dehydration was 10.5 h, 5 h and 3.5 h in case of tray drying and 6.5 h, 6 h and 5.5 h in case of microwave oven drying at 40^{0}C, 50^{0}C, 60^{0}C for tray drying and 10 sec., 1 min. and 2 min. duration for microwave oven drying, respectively (Table 1).

Effect of dehydration time on rate of dehydration :

The relationship between dehydration time and drying rate for various treatments is plotted and shown in Fig 5, the rate of dehydration showed decreasing trend with increase in dehydration time. The cause of falling off in the rate of dehydration was due to the inability of the moisture to be conveyed from the center of body to the surface at a rate comparable with moisture evaporation from its surface to the surroundings.

Quality of dehydrated products :

The results on quality of dehydrated samples *viz.*, rehydration ratio, ascorbic acid are given below:

Ascorbic acid content :

The ascorbic acid of fresh math (*Amaranthus cruentus*) was 48.52 mg /100g.The variation in ascorbic due to effect of dehydration is shown in Fig.6.

Table 1: Effect of dehydration temperature on dehydration time for removal of moisture upto bone dry weight

Sr. No.	Treatments	Dehydration time (hr)	Initial weight (g)	Bone dry weight (g)	% moisture removed	
					w.b.	d.b.
1.	40°C (T_1)	10.5	30	3.976	89.90	899.001
2.	50°C (T_2)	5	30	5.503	90.10	910.101
3.	60°C (T_3)	3.5	30	3.45	90.15	915.228
4.	10 sec. (T_4)	6.5	50	7.508	89.95	895.025
5.	1 min. (T_5)	6	50	8.070	90.10	910.101
6.	2 min. (T_6)	5.5	50	6.761	90.15	915.228

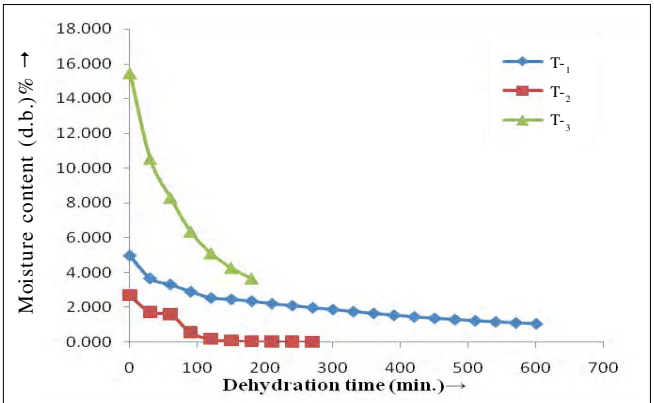

Fig 5: Effect of dehydration time on rate of dehydration

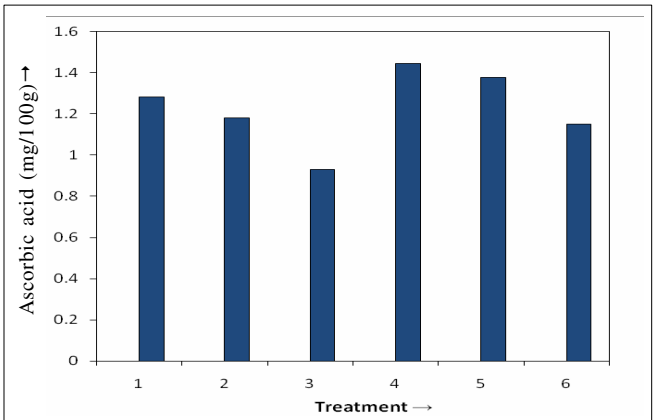

Fig 6: Effect of dehydration on ascorbic acid content of math

It was observed that there was decrease in ascorbic acid due to dehydration of math. The results are shown in Fig.6. The maximum decrease in ascorbic was seen in case of sample dehydrated at 60^{0}C (0.929 mg/100g) followed by sample dehydrated at 55^{0}C (1.182 mg/100g) and maximum retention of ascorbic acid was found in case of tray drying sample dehydrated at 40^{0}C (1.282 mg/100g). In case of microwave oven drying decrease in ascorbic acid in case of sample dehydrated at 2 min. (1.249 mg/100g).

In case of microwave oven drying minimum ascorbic acid was decreased as compared to tray drying dehydrated sample.

Rehydration test :

After dehydration, rehydration of math was carried out. The weight gain in the rehydrated sample were noted for tray dried sample and microwave sample of different temperature and durations 40^{0}C, 50^{0}C, 60^{0}C and 10 sec., 1 min., 2 min., respectively.

Rehydration ratio varied between 4.03 to 4.20. It was maximum in case of treatment T_5 and it was minimum in case of treatment T_2 (Table 3).

Organoleptic properties of dehydrated math :

The sensory evaluation was done for organoleptic properties *viz.,* colour, flavour and taste. The results are shown in Table 4. It was found that colour, taste and flavour of microwave oven dried sample at duration of 10 sec. were liked moderately for most of the judges. Colour and taste of tray dried at 40^{0}C liked slightly for most of the judges. Other samples have intermediate score. All the treatments were

Table 2 : Variation in ascorbic acid of math due to dehydration

Sr. No.	Treatments	Ascorbic acid (mg/100g)
1.	T_1	1.282
2.	T_2	1.182
3.	T_3	0.929
4.	T_4	1.445
5.	T_5	1.377
6.	T_6	1.249

Table 3 : Weight gain and rehydration ratio for all treatments

Sr. No.	Treatments	Weight gain (g)	Rehydration ratio
1.	T_1	8.13	4.065
2.	T_2	8.06	4.03
3.	T_3	8.25	4.125
4.	T_4	8.2	4.1
5.	T_5	8.4	4.2
6.	T_6	8.3	4.15

homogeneous with respect to colour, flavour and taste.

Colour analysis :

Colour of math sample after dehydration was measured by using colour Flex Meter (Hunter lab USA make). The results for tray drying and microwave oven drying are shown in Table 5 and 6.

Conclusion :

– Ascorbic acid content reduced due to dehydration. It showed decreasing trend with increase in temperature in case of mechanical drying as well as in microwave oven drying.
– Maximum retention of ascorbic acid was found in case of microwave oven drying at duration of 10 sec.
– Maximum loss of ascorbic acid was in case of tray drying at 60^0C.
– Drying of fenugreek was observed in the falling rate period of drying.
– The total dehydration time found were 10.5h, 5h, 3.5h for tray drying and 6.5h, 6h, 5.5 h for microwave oven drying.
– There was no significant difference between the

Table 4: Sensory evaluation

Sr. No.	Treatments	Colour	Taste
1.	T_1	6.67	7.44
2.	T_2	5.55	7.11
3.	T_3	4.66	6.44
4.	T_4	7.11	7.8
5.	T_5	6.11	7.22
6.	T_6	5.44	6.77

Table 5 : Colour analysis of tray dried math

Sample ID	L	a	b	YI D1925(2/C)	WI CIE
TD MATH Temp. 60°C- 10	24.16	3.3	5.25	50.51	-97.26
TD MATH Temp. 60°C- 9	24.4	3.21	5.39	49.96	-99.2
TD MATH Temp. 60°C - 8	24.04	3.05	5.71	52.24	-108.56
TD MATH Temp. 60°C - 7	24.07	3.05	5.39	50.63	-101.2
TD MATH Temp. 60°C - 6	23.88	3.05	5.77	54.1	-110.99
TD MATH Temp. 60°C - 5	24.17	3.29	5.48	50.58	-102.33
TD MATH Temp. 60°C - 4	24.02	3.26	5.62	52.6	-106.39
TD MATH Temp. 60°C - 3	24.34	3.27	5.66	52.07	-105.48
TD MATH Temp. 60°C - 2	24.28	3.53	5.49	52.5	-101.75
TD MATH Temp. 60°C - 1	24.3	3.25	5.78	53.52	-108.46

Table 6 :Colour analysis of microwave oven dried math

Sample ID	L	a	b	YI D1925(2/C)	WI CIE
MD MATH Time-2min.- 10	27.33	-0.04	7.84	51.29	-139.35
MD MATH Time-2min.- 9	27.2	0.2	7.63	50.78	-135.24
MD MATH Time-2min.- 8	27.12	-0.03	7.69	50.46	-137.46
MD MATH Time-2min.- 7	27.31	0.07	7.84	51.41	-139.2
MD MATH Time-2min.- 6	27.29	0.18	7.6	50.32	-133.93
MD MATH Time-2min.- 5	27.15	-0.07	7.58	49.95	-134.67
MD MATH Time-2min.- 4	27.36	0.08	7.7	50.31	-135.71
MD MATH Time-2min.- 3	27.15	-0.03	7.68	50.46	-136.82
MD MATH Time-2min.- 2	27.04	0.19	7.49	50.18	-133.24
MD MATH Time-2min.- 1	27.15	0.1	7.56	50.03	-134.18

treatments. All the treatments were homogeneous with respect to colour, flavour and taste.

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REFERENCES

Jayaraman, K.S., Das, D.K. Gupta and Rao. N. (1991). Quality characteristics of some vegetables dried by direct and indirect sun drying. *Indian Food Packer.*, **45**(1): 16-23.

Lidhco, C. K. (2006). Effect of hot air drying temperature on brinjal quality. *Indian Food Packer.*, **60**(5): 46-48.

WEBLIOGRAPHY

Anonymous (2008). Nutrient Packed Leaves.@http://*www.food.sify.com*/fullstory.php.

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