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RESEARCH ARTICLE

Effect of drying on iron and vitamin C content of selected vegetables

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ABSTRACT

The green leafy vegetables *viz.* cabbage, fenugreek leaves and spinach and three other vegetables *viz.* cluster bean, cauliflower and okra were dried in cabinet tray dryer, in sunlight and under shade. The selected vegetables were biochemically analysed for the estimation of vitamin C, total iron and bioavailability of iron in fresh and dried form. The cabinet tray dried samples showed 83.33 to 96.65 per cent retention of total iron, cabinet tray dried vegetable samples retained highest ionisable iron content as compared to shade dried and sun dried vegetable samples. The drying process influenced significantly ($P<0.05$) the ionisable iron content of all the selected vegetables except for cluster bean. Vegetables dried in cabinet tray dryer exhibited the highest per cent bioavailability of iron as compared to sun dried and shade dried vegetables. Process of drying influenced significantly the per cent bioavailability of iron of all the selected vegetables except for cabbage and cluster bean. The per cent retention of vitamin C of cabinet tray dried vegetable samples was significantly higher as compared to the remaining two modes of drying used under study. Cabinet tray drying was found to be superior in respect of retention of vitamin C, total iron and bioavailability of iron in selected vegetables as compared to sun drying and shade drying.

Key words : Drying, Vegetables, Vitamin C, Total iron, Bio-availability of iron

INTRODUCTION

Vegetables are important part of our daily diet. Vegetables perform for better than just decorating the dinning table. They increase the resistance power and improve health of human beings. Vegetables and fruits are the main sources of vitamins and minerals. Production of vegetables is seasonal and the market will be over flooded during peak seasons at particular period. As this commodity being perishable, the spoilage of large quantity of vegetables occurs due to the abundant supply during season. The market glut and huge wastage can be prevented by preserving the vegetables. Considering the low bulk density of dried vegetables, drying is considered to be the most suitable and easy method of preservation.

As fresh vegetables are rich sources of vitamin C and good sources of minerals, it should be included in daily diet. However, vegetables are not available in some conditions such as in off season or for people on front. Even vegetables can not be cultivated in some areas due to climatic conditions. Thus, due to such reasons, fresh vegetables are not available to be included in daily diet. In such situations, preserved vegetables can fill up the gap to some extent.

Iron deficiency (anaemia) is one of the most prevalent deficiency diseases throughout the world.Dietary iron deficiency is the main cause of anaemia and suggestive cause for this situation is a low availability of dietary iron. Most of the commonly consumed foods are poor sources of iron. Indian population depends largely on vegetables for supply of iron. Hence, a large amount of vegetables need to be included in daily diet. If vegetables are dried and included in the diet, from a small amount of bulk relatively large amount of iron can be made available through it. Hence, it can be helpful in prevention of iron deficiency anaemia.

About 90 per cent of a person's dietary vitamin C requirement is obtained from fruits and vegetables. When fresh fruits and vegetables are not available in some situations, dried vegetables can serve this purpose by providing some amount of vitamin C through it. Drying vegetables result into both nutrient and culinary losses.

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The losses however vary with the drying technique employed (Negi and Roy, 2001). Though loss of vitamin C occurs during drying certain amount of vitamin C is retained in it even after drying.

The data available on effect of drying on total iron and bioavailability of iron are scanty. Hence, the present investigation has been undertaken to find out the effect of different drying methods on total iron, bioavailability of iron and vitamin C of selected vegetables.

MATERIALS AND METHODS

Three green leafy vegetables namely, cabbage (*Brassica oleracea* L.) fenugreek leaves (*Tringonella foenumgraceum*), spinach (*Spinacia oleracea*) and commonly consumed three other vegetables namely, cauliflower (*Brassica oleracea*) cluster bean (*Cyamopsis tetragonoloba* L.) and okra (*Abemoschus esculentus*) were purchased from the local market in a lot.

The damaged portion of vegetables was discarded and vegetables were cleaned. Roots and hard stems of fenugreek leaves were trimmed off. In case of spinach, stalks were removed. Cabbage and cauliflower were cut into uniform size of 2 cm. Okra and cluster beans were taken as such however, only non-edible parts were removed. The selected vegetables were dried separately in sunlight, under shade and in cabinet tray dryer from the month of February to May 1999. Five g vegetable was placed in Petri dish and kept in cabinet tray dryer for drying. The temperature in dryer was 55^0C ± 2^0C. One lot of Petri dishes was kept in a enamel tray and exposed to direct sunlight and another lot was placed in shade in the laboratory for drying. All the vegetable samples were dried up to 8-10% moisture level. The maximum temperature under open sunlight varied from 31.8 to 43.8^0C. The maximum and minimum atmospheric humidity during experimental period ranged from 40 to 79 per cent and 15 to 38 per cent, respectively. The wind velocity was recorded to be 3.0 to 5.6 km / hr.

Fresh and dried vegetables were analyzed in laboratory for biochemical estimations. Total iron content of fresh and dried vegetables was estimated by $\alpha - \alpha$ dipyridyl method (A. O. A. C., 1975). Bioavailability of iron from the samples of selected vegetables in fresh and dried form was assessed by the *in vitro* method of Narsinga Rao and Prabhavati (1978) and vitamin C content of fresh and dried vegetables was estimated by Dye method (A. V. C., 1966). The results were statistically analysed by applying one way analysis of variance technique.

RESULTS AND DISCUSSION

Table 1 shows data on total iron content of selected vegetables before and after drying. The content of total iron in selected vegetable samples in fresh form ranged from 2.28 mg to 9.86 mg per 100 g of vegetables. The cabinet tray dried samples showed 83.33 to 96.65 % retention of total iron content while sun dried and shade dried vegetable samples showed 65.97 to 86.51% and 78.47 to 91.31 % retention of total iron, respectively. The shade dried samples had total iron values at par with values of total iron of cabinet tray dried vegetables except for fenugreek. However; significantly higher total iron content was noticed in shade dried vegetables as compared to sun dried vegetable samples. The iron content of all dried vegetables was obtained from small bulk of vegetables, which was obtained after drying.

Studies conducted by various scientists from different parts of the world showed that different drying conditions did not bring significant change in mineral content of vegetables (Goyal and Mathew, 1990; Gothwal *et al.*, 1998). Oladele and Aborisade (2009) reported that the minerals contents decreased slightly with drying The estimated values of total iron in present investigation also reported the non-significant change in total iron content of vegetables after mechanical dehydration. The observed changes in total iron content after drying vegetables in

Table 1 : Effect of different modes of drying on the total iron content of the selected vegetables

Name of the vegetable	Total iron content (mg/100g)				S.E.±	C.D. (P=0.05)
	Initial value	Cabinet tray dried	Sun dried	Shade dried		
Cabbage	2.88	2.40 (83.33)	1.90 (65.97)	2.26 (78.47)	0.07	0.229
Cauliflower	3.57	3.40 (95.23)	2.53 (70.86)	(91.31)	0.06	0.223
Cluster bean	3.45	3.20 (92.75)	2.46 (71.30)	3.13 (90.72)	0.14	0.45
Fenugreek	9.86	9.53 (96.65)	8.53 (86.51)	8.86 (89.85)	0.08	0.26
Okra	2.28	2.12 (92.98)	1.86 (81.57)	2.06 (90.35)	0.05	0.16
Spinach	4.56	4.40 (96.49)	3.60 (78.94)	4.13 (90.57)	0.11	0.37

Values given parenthesis denote the per cent retention open sun and shade may be due to effect of temperature and exposure of vegetables to atmosphere. Though there was reduction in total iron content of dried vegetables, they still found to be containing remarkable amount of iron even after drying by various modes.

It can be concluded from the above results that the process of cabinet tray drying of vegetables did not influence the total iron content in them.

Table 2 represents data on ionisable iron content of selected vegetables. Fenugreek contained highest initial ionisable iron (1.86 mg) while okra was found to be containing lowest (0.12 mg) initial ionisable iron. Among the drying modes, cabinet tray dried vegetable sample recorded highest ionisable iron content in selected vegetables. The shade dried vegetables retained higher ionisable iron as compared to sun dried vegetables. The retention of ionisable iron in sundried vegetable samples varied from 9.23 to 76.34%. The ionisable iron content of cluster bean was not influenced by any method of drying used during the experiment. The results depicted that ionisable iron content of different vegetables responded differently due to drying process. This difference in ionisable iron content may be due to structural and compositional differences in individual vegetable.

It is concluded that cabinet tray dried vegetables had better retention of ionisable iron than shade dried and sun dried vegetable samples. The drying process influenced significantly ($P<0.05$) the ionisable iron content of all the selected vegetables except for cluster bean.

Table 3 depicts the effect of different modes of drying on bioavailability of iron of selected vegetables. The initial per cent of bioavailability of iron of selected vegetables ranged from 2.76 per cent to 9.41 per cent. The drying process caused statistically significant ($P<0.05$) reduction in per cent bioavailability of iron of all the selected vegetables except for cabbage and cluster bean. Among the different modes of drying, the cabinet tray dried samples exhibited the highest per cent bioavailability of iron while sun dried samples recorded lowest per cent bioavailability of iron in selected vegetables. Shade dried samples exerted intermediate effect on per cent bioavailability of iron of selected vegetables.

It can be concluded from above results that process of drying influenced significantly the per cent bioavailability of iron of all the selected vegetables except for cabbage and cluster bean.

Table 4 indicates effect of drying methods on vitamin C content of selected vegetables. The vitamin C content in the studied vegetables ranged from 21.14 mg to 117.48 mg per 100 g of fresh vegetable. The results revealed that vitamin C content of all the vegetables under study influenced significantly by various modes of drying. The retention of vitamin C was found to be highest in okra (58.79%) after cabinet tray drying whereas, it was lowest in spinach (22.85%) after drying it in open sun. The retention of vitamin C of cabinet tray dried vegetable samples ranged from 35.54% to 58.79%. The sun dried vegetable samples showed 22.85% to 31.8% retention of vitamin C while the vitamin C retention ranged from 30.44% to 47.87% in shade dried vegetables. Cabinet tray dried samples retained more vitamin C, while sun dried samples showed less retention of vitamin C. Shade dried vegetables showed mediocre retention of vitamin C.

The observed highest loss of vitamin C during sun drying as compared to the other two drying modes may be due to the sensitivity of vitamin C to atmospheric conditions like oxygen, light and temperature. The maximum retention of vitamin C in cabinet tray dried samples must be because of the controlled conditions and exposure of vegetables to temperature and air for short time.

It can be concluded from results that drying affected the vitamin C content of vegetables. Losses in vitamin C occurred during drying process. Cabinet tray dried vegetables retained more vitamin C as compared to sun and shade dried vegetable samples. Severe losses in vitamin C occurred during the sun drying. The results of present investigation are in conformity with the results reported

Table 2 : Effect of different modes of drying on the ionisable iron content of the selected vegetables

Name of the vegetable	Ionisable iron (mg/100g)				S.E.±	C.D. (P=0.05)
	Initial value	Cabinet tray dried	Sun dried	Shade dried		
Cabbage	0.14	0.098 (70.00)	0.024 (17.14)	0.048 (34.28)	0.021	0.069
Cauliflower	0.26	0.226 (86.92)	0.024 (9.23)	0.212 (81.53)	0.024	0.080
Cluster bean	0.22	0.196 (89.09)	0.122 (55.45)	0.172 (78.18)	0.026	NS
Fenugreek	1.86	1.711 (91.93)	1.420 (76.34)	1.540 (82.79)	0.045	0.14
Okra	0.12	0.072 (60.00)	0.024 (20.00)	0.072 (60.00)	0.014	0.04
Spinach	0.50	0.48 (96.00)	0.17 (34.00)	0.360 (72.00)	0.062	0.20

Values given parenthesis denote the per cent retention

Table 3 : Effect of different modes of drying on bioavailabilty of iron of the selected vegetables

Name of the vegetable	Bioavailability of iron (mg/100g)				S.E. ±	C.D. (P=0.05)
	Initial value	Cabinet tray dried	Sun dried	Shade dried		
Cabbage	2.76	2.34 (84.78)	1.07 (38.76)	1.48 (53.62)	0.40	NS
Cauliflower	3.86	3.60 (93.26)	0.93 (24.09)	3.53 (91.45)	0.34	1.13
Cluster bean	3.55	3.36 (94.64)	2.79 (78.59)	3.02 (85.07)	0.45	NS
Fenugreek	9.41	8.94 (95.00)	8.31 (88.31)	8.65 (91.92)	0.21	0.70
Okra	2.99	2.08 (69.56)	1.08 (36.12)	2.12 (70.90)	0.29	0.96
Spinach	5.63	5.60 (99.46)	2.72 (48.31)	4.61 (81.88)	0.66	2.14

Values given parenthesis denote the per cent retention

Table 4 : Effect of different modes of drying on vitamin C content of the selected vegetables

Name of the vegetable	Vitamin c (mg/100g)				S.E. ±	C.D. (P=0.05)
	Initial value	Cabinet tray dried	Sun dried	Shade dried		
Cabbage	117.48	52.57 (44.74)	37.37 (31.80)	44.52 (37.89)	1.20	3.91
Cauliflower	54.56	24.62 (45.12)	15.33 (28.09)	20.05 (36.74)	1.38	4.49
Cluster bean	46.40	17.82 (38.40)	10.63 (22.90)	17.57 (37.86)	1.38	4.51
Fenugreek	50.81	18.06 (35.54)	11.68 (22.98)	15.47 (30.44)	0.62	2.04
Okra	21.14	12.43 (58.79)	5.87 (27.76)	10.12 (47.87)	1.42	4.64
Spinach	28.83	13.42 (46.54)	6.59 (22.85)	10.48 (36.35)	1.48	4.84

Values given parenthesis denote the per cent retention

by Goyal and Mathew (1990) who observed significant reduction in vitamin C content during sun drying. Maximum retention of vitamin C during mechanical drying was noticed by Pawar *et al.* 1988, Onayemi and Badifu, 1987. Ramallo and Mascheroni (2004) recorded maximum retention of ascorbic acid when drying temperature was fixed at 45^0C. Oboh and Akindahunsi (2004) also found a significant decrease in vitamin C content of some sun dried leafy vegetables.

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