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Nutrient Losses of Green Leafy Vegetables during Dehydration

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Abstract—*The study was designed to estimate loss of nutrients during dehydration of cauliflower leaves using following dehydration techniques - (i) Unblanched sun drying, (ii) Blanched sun drying, (iii) Unblanched shade drying, (iv) Blanched shade drying, (v) Unblanched cabinet drying, (vi) Blanched cabinet drying.*

For blanched variations, the temperature and time of blanching was standardized at 90^0C for two minutes by peroxidase inactivation test. Standardised techniques were used for sun and shade drying. Cabinet drying was standardized at 65 ± 5^0C for 2½ hours.

Carotene losses in blanched dehydrated samples were 18%, 31% and 39% for cabinet, shade and sun dried leaves, while for unblanched dehydrated samples, these were 26%, 44% and 50% respectively. Thus, blanched cabinet drying technique was found to be most suitable for reducing carotene losses.

Iron losses were negligible in unblanched samples, while blanched samples had around 19% iron loss. These losses could be reduced by using the technique of 'serial blanching' and 'air cooling'. Prepared leaf powder provided 56 mg iron and 38,500 µg carotene per 100 g.

INTRODUCTION

Sun drying has been used traditionally to dehydrate green leafy vegetables, however this technique can lead to high losses of heat sensitive nutrients (my). Along with sun drying, shade drying technique, where the material to be dried is protected from direct sunlight has also been used.

In a study conducted in Tanzania on effect of drying methods on spinach (Amaranthus aquatics) and pumpkin leaves (toll-free occidentals), revealed higher losses of beta carotene in sun-drying in comparison to shade drying. The losses of carotene were higher in pumpkin leaves [2].

Faster techniques, like cabinet dehydration have also been experimented. In a study from Nigeria on *Moringa Oleifera* leaves showed higher levels of vitamin A, vitamin C and protein in leaves, dried at 60°C in dehydrator in comparison to sunbor shade drying. Shade drying was better than sun drying, however, it required very long duration for proper drying of leaves [3]. The long duration of sun/shade drying leads to oxidation of carotenoids. Ultraviolet rays from the sun also play a role in the destruction of carotene during sun drying [4]. Sun drying of amaranth and spinach led to 49% loss of carotene while it was only 14% by cabinet drying [5].

Enzymatic reactions can bring about loss of nutrients in dehydrated vegetables. Therefore, blanching has often been employed before dehydration. The role of blanching in reducing carotene and ascorbic acid content has been reported [6]. Blanched samples show better retention of carotenoids due to destruction of enzymes responsible for oxidation of carotenoids.

However, during blanching there is rupture of cell walls, which can lead to leaching of some nutrients. Blanching of different varieties of cassava and amaranth leaves led to 20.3 to 50% decrease in total ash content due to leaching [7]

Traditional techniques of prolonged heating during blanching can also lead to excessive loss of carotenoids due to excessive wilting and damage of leaf tissues that will increase leaching losses; oxidation and isomerization of beta carotene from trans to less active cis isomers, and excessive activity of lipo oxigenase enzyme during initial stages (warming) of blanching. Blanching losses of carotene in spinach and amaranth increased from 8 to 26% when blanching time was increased from 5 to 15 minutes [5].

Thus, there is a clear need to standardize techniques of dehydration and blanching so as to reduce nutrient losses. The specific objectives of the present study were

1) To estimate and compare the loss of nutrients during dehydration of leaves.
2) To develop and standardize the technique of preparing leaf powder with maximum retention of nutrients especially carotene and iron.

METHODOLOGY

In the present study cauliflower leaves were selected for dehydration as they are a rich source of micronutrients and available free of cost in India. Traditionally, only the flower part of cauliflower is eaten, and the leaves are discarded.

The techniques used for drying cauliflower leaves were:

1) Unblanced sundrying
2) Blanched sundrying
3) Unblanched shade drying
4) Blanched shade drying
5) Unblanched cabinet drying
6) Blanched cabinet drying

For blanched variations, the temperature and time of blanching was standardized with peroxidase test [8] so as to prevent overblanching. The time and temperature for optimal blanching of cauliflower leaves was two minutes at 90°C as tested by peroxidase test.

For sun drying, the leaves were kept directly under the sun while for shade drying, they were protected from direct sunlight. Cabinet drying was standardized at 65+50C for 2.5 hours.

The dehydrated leaves must have final moisture content of less than 6% as per ISI specifications The leaves, dehydrated by different techniques were analyzed for their moisture content to find out if drying was complete or not.

After drying, cauliflower leaves were powdered in electric grinder and sieved. Different samples were stored separately in polythene aluminium laminated bags and analyzed for their moisture, iron[10] and carotene content[11].

RESULTS

The main findings of the study were:

1. Time taken in Dehydration

During summers (max. outside temp. 38-400C), unblanched cauliflower leaves could be dehydrated in 30, 96 and 3 hrs and blanched leaves in 10.14 and 2.5 hrs by sun, shade and cabinet drying techniques respectively.

It was clear from results that thick, unblanched cauliflower leaves took very long to dehydrate by sun or shade drying while blanching was helpful in reducing the time of dehydration. During blanching there is rupture of cell walls, which leads to faster evaporation during dehydration.

Dehydration was fastest by cabinet drying and slowest by shade drying. Unblanched shade dried cauliflower leaves could not be dehydrated to required moisture level of below 6% even after 96 hrs. And had to be dried in a pan over the fire for about 2 minutes to remove moisture to desired level.

During winter (max. temp. 28-300C) drying took even longer by sun / shade drying while cabinet drying was not affected by weather conditions.

One kilogram of fresh, destalked cauliflower leaves produced 90 to 100 g of leaf powder (LP) i.e. a yield in the range of 9 to 10%. Yield was dependent on moisture content of leaf, the moisture of the prepared LP and the extent of loss of water-soluble nutrients during blanching.

2. Yield

One kilogram of fresh, destalked cauliflower leaves produced 90 to 100 grams of leaf powder (LP) i.e. a yield in the range of 9 to 10%. Yield was dependent on moisture content of leaf, moisture of prepared LP and the extent of loss of water soluble nutrients during blanching.

3. Carotene Content of Leaf Powders

The carotene content of leaf powders prepared by different techniques is given in Table -1:

Table: 1 Moisture and carotene content of prepared Leaf Powders

Technique	Moisture	Carotene (µg/100g) (fresh weight basis)	Carotene (µg/100g) (dry weight basis)	%loss of carotene (dry weight basis
FRESH CAULIFLOWER LEAVES	91	4,597	51,078	-

LEAF POWDER

Cabinet dried				
Blanched	4.5	39,999	41 ,884	18
Unblanched	5.0	35,908	37,798	26
Shade dried				
Blanched	5.1	33,447	35,244	31
Unblanched	4.2	27,403	28,604	44
Sun dried				
Blanched	5.5	29,442	31,156	39
Unblanched	5.8	24,058	25,539	50

Fresh cauliflower leaves had 51,078 µg of carotene per 100 g on dry weight basis. Calculation of carotene content on dry weight basis in different leaf powder samples revealed values from a minimum of 25,539 µg/100g in unblanched sun dried sample to a maximum of 41 ,884 µg/100g in blanched cabinet dried sample. Blanching by inactivating the enzymes was helpful in reducing carotene losses in all three techniques of dehydration.

It was evident from the results that blanched cabinet drying technique was most suitable as it led to maximum retention of carotene and only 18% carotene was lost during processing. Shade drying, though took longer than sun drying, led to lower carotene losses, i.e., 31 and 44% of blanched and unblanched samples in comparison to 39 and 50% losses respectively in the sun drying.

4. Iron Content of leaf powders:

The iron content of leaf powders prepared by different techniques is given in Table-2

Table 2: Iron content of prepared Leaf powder

Technique	Moisture	Iron (mg/l00g) (fresh weight basis)	Iron (mg/l00g) (dry weight basis)	Percent loss (-) or gain (+) of iron (dry weight basis
FRESH CAULIFLOWER LEAVES	91	5.74	63.78	-
LEAF POWDER				
Cabinet dried				
Blanched	4.5	49.32	51.64	-19.03
Unblanched	5.0	60.44	63.62	-0.25
Shade dried				
Blanched	5.1	53.26	56.12	-12.01
Unblanched	4.2	67.00	69.93	+9.6
Sun dried				
Blanched	5.5	55.12	58.32	-8.6
Unblanched	5.8	64.51	68.48	+7.4

Fresh cauliflower leaves on dry weight basis had 63.78 mg iron/100 g. Prepared LP samples had iron content in the range of 51.64 to 69.93 mg/100 g on dry weight basis.

In cabinet dried samples, blanched leaves sample lost 19% iron while unblanched sample lost only 0.25% iron. This indicated to leaching losses of iron during blanching. Awoyinka has also reported a 23 % loss in iron due to blanching in cabinet dried cassava leaves [7].

Blanched samples in shade and sun drying lost 12% and 9% iron respectively. However, unblanched samples of shade and sun drying technique gained 10% and 7% iron respectively. This extra iron could not have come from knives or utensils as only stainless steel knives or utensils were used. However, this trend of higher iron content in open air drying techniques was always there even in repeated trials. This iron probably came from dust in the air, to which leaves were exposed for long hours during open drying techniques. A similar trend of higher content in sun dried powders of curry, mint and gogu leaves in comparison to their respective cabinet dried samples has been reported [12]. Iron originating from exogenous sources, like soil, dust and water is called 'contaminant iron'. Analysis of data on iron absorption from meals consumed in various Asian countries showed that, up to 50% of iron consumed was 'contaminant iron' [13].

5. Reduction in leaching losses of iron during blanching

During the initial stages of developing the process for LPC preparation, following steps had been taken to reduce leaching losses:

1) Destalking and midrib removal of leaves was not done prior to washing the leaves but was done only after washing the leaves.
2) Exact blanching temperature required was estimated (by Peroxidase test) so as to prevent over blanching and thereby reducing leaching losses.

To further reduce leaching losses of iron it was decided to try the technique of serial blanching i.e.. using the same blanching water many times as suggested by Luh and Woodroo (14). Buildup of leached out mineral in the blanching water up to saturation level helps to reduce the leaching process.

To study the impact of serial blanching on leaching losses of iron, one sample of leaves was serial blanched i.e., same water was used repeatedly for blanching, while another sample of leaves was blanched by a plain blanching technique where water for blanching was used only once. The rest of the process of cooling in water after blanching, cabinet drying and grinding to prepare LP - was same in both the samples.

Iron on dry weight basis was 60mg/100 g in the serial blanched sample and was 55.16mg/100 g in plain blanched sample. Thus, serial blanched sample had 8.8% more iron in comparison to plain blanched sample, indicating to role of serial blanching in decreasing leaching of iron. This technique also saved on fuel and water consumption.

As a normal practice, dipping vegetables in cold water so as to prevent over blanching always follows the process of blanching. In the present study also, after blanching, leaves were always dipped in cold water to bring them to room temperature and then they were spread on trays for dehydration. It was felt that this step of dipping destalked, blanched leaves in water could also be responsible for leaching of iron and other water-soluble nutrients. Thus, to further reduce leaching losses, it was decided not to cool leaves in water after blanching but to directly spread them on dehydration trays after blanching.

However, by doing so, leaves remained at a comparatively higher temperature for a longer time, as these were not immediately water cooled and only gradually got cooled by air. It was felt that this might affect their carotene content negatively. Therefore, it was decided to prepare LP using both water-cooling and air cooling techniques after blanching and to measure their iron and carotene content.

The carotene and iron content of cabinet dried LP samples prepared by serial blanching, but with different cooling techniques, are given in Table-3.

Table 3: Effect of cooling treatment after blanchinq. on iron and carotene content of cabinet dried LPC.

After blanching, cooling treatment	Moisture (%)	IRON (mg/100g)		CAROTENE (µg/100g)	
		(fresh weight basis)	(dry weight basis)	(fresh weight basis)	(dry weight basis)
Air cooled (not cooled in water	5.4	56.00	59.20	38,500	40,698
Water cooled	5.0	50.58	53.24	39,050	41,105

Air-cooled sample had 59.2 mg iron and 40,698 pg carotene per 100 g (on dry weight basis) of LP, while water cooled sample had 53.24 mg iron and 41,105 mg carotene per 100 g (on dry weight basis). Thus, it was clear that air cooling helped in decreasing leaching losses of iron as air cooled sample had 11.2% more iron than water cooled sample. The content of carotene in water cooled sample was only 1.0% more than air cooled sample. Thus, it was decided to use air-cooling technique for further processing trials. Also, this procedure saved time, water and might have also reduced leaching of other water soluble nutrients.

CONCLUSION & PRACTICAL APPLICATION

It was clear from the study that a Leaf Powder rich in iron and carotene could be prepared from cauliflower leaves. Technique of 'Blanched Cabinet Drying' was most suitable for carotene retention, while leaching losses of iron could be reduced by adopting 'serial blanching' and 'air cooling' technique.

Different batches of leaf powders prepared by this standardized technique revealed its mean iron and carotene content (on fresh weight basis) per 100g to be 56mg and 38,500 mg, respectively. It was clear that dehydrated cauliflower leaf powder could be used as a 'natural fortificant' in supplementary feeding to alleviate micronutrient malnutrition.

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