Quality characteristics of dehydrated leafy vegetables influenced by packaging materials and storage temperature

Uadal Singh and V R Sagar
Division of Post Harvest Technology, Indian Agricultural Research Institute, New Delhi 110 012, India

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Leafy vegetables (curry leaves and drumstick leaves) were dehydrated in cabinet drier at 58±2°C and packed in four packaging materials (200 gauge and 400 gauge LDPE, 200 gauge HDPE and 150 gauge PP) and stored at room temperature (RT) and low temperature (LT) for 3 months to evaluate best package and storage temperature for maximum retention of nutrients in leafy vegetables during storage. HDPE (200 gauge), followed by storage at LT (7±1°C), was found to be good for higher retention of β-carotene, ascorbic acid, chlorophyll content, rehydration ratio, sensory score and less moisture and non-enzymatic browning (NEB) in dehydrated vegetable leaves during 3 months of storage.

Keywords: β-carotene, Chlorophyll, Curry leaves, Drumstick leaves, Drying, Storage

Introduction

India is second largest producer of vegetables in the world after China, accounting for 10% of world production. In India, different varieties of green leafy vegetables (LV) are available during winter season. LV are relatively inexpensive, easily and quickly cookable and rich in several nutrients [â-carotene, riboflavin, folic acid, minerals like calcium (Ca), iron (Fe) and phosphorus (P) and fair source of protein (2-7%)]. Processing by dehydration makes LV light in weight and can be easily converted into fresh-like form throughout the year. This study presents suitable packaging material and storage condition for selected dehydrated LV.

Experimental Section

LV of curry leaves [CL, Murraya koenigii (Linn.) Spreng.] and drumstick leaves (DL, Moringa oleifera Lam.) were procured from experimental farm of Division of Vegetables Science and brought to Division of Post Harvest Technology, IARI, New Delhi to evaluate effect of packaging material and storage temperature on quality of dehydrated leaves. Both vegetables were washed in running tap water thoroughly; yellowish and unwanted leaves as well as hard stems were removed, and resultant leaves were trimmed manually.

Standardization of Blanching Time and Dehydration of Leaves

A known quantity of CL and DL were taken in a muslin cloth and dipped in boiling water containing 0.5% sodium metabisulphite (SMS) (1:5, leaves: water) for 15, 30, 45, 60, 90, 120 and 150 s to inactivate enzymes. Blanching time was standardized by enzyme test in presence of guaicol and hydrogen peroxide. Pretreated leaves (CL and DL) were spread on an aluminium tray (1.05 m x 0.45 m) @ 1.5 kg/m² and dried in cross flow hot air (airflow rate of 1.20-1.80 m/s) at 58±2°C (Kilburn make, model-0248) cabinet drier to a moisture content of 4-5% in finished product.

Packaging and Storage

Dehydrated CL and DL were packed in different packaging materials [200 gauge LDPE (low density polyethylene) pouches, 400 gauge LDPE pouches, 200 gauge HDPE (high density polyethylene) pouches and 150 gauge PP (poly propylene) pouches]. Packed samples were stored at room temperature (RT) (15-35°C) and low temperature (LT) (7±1°C) up to three months for storage study and product was drawn at one month interval for physico-chemical analysis.
Physico-chemical Analysis

Moisture content (%) was determined by drying a known weight of sample in a hot air oven at 60±5°C to a constant weight. Chlorophyll, β-carotene, ascorbic acid and non enzymatic browning were determined according to reported procedure.

Rehydration Ratio (RR)

Dehydrated samples (5 g each) were put into a beaker and 50 ml of warm (60°C) water was added. After ½ h, drained weight of dehydrated material was taken.

Sensory Analysis

Overall acceptability (colour, flavour and texture), was evaluated by a panel of 7 semi trained members. Samples were presented after rehydration in tap water. Attributes were scored on 5 point hedonic scale (excellent, 1; good, 2; fair, 3; poor, 4 and very poor, 5).

Statistical Analysis

Data was subjected to statistical analysis [critical difference (CD) at 5% level of probability was compared for comparison among different treatments]. All treatments were replicated 3 times.

Results and Discussion

Relative Humidity (RH)

Data are relationship between equilibrium moisture content (EMC) and number of days to reach equilibrium at particular RH (Table 1) and RH curve (Fig. 1). Product retained its quality of overall acceptability up to 60% RH and below in both dried
vegetables. At higher levels of RH, products absorbed moisture and turned dark and fungal growth (Aspergil- 
lus sp. and Penicillium sp.) was observed at 80% RH 
and above. Optimum RH for dehydrated CL and DL was 
60% or below for safe storage and shelf life. Critical 
and danger point in terms of moisture level for CL 
(12.01%, 11.12%) and DL (11.21%, 9.15%), were 
observed when initial moisture content in dehydrated CL 
and DL was 2.5% and 5.50% respectively. A similar trend 
is reported in onion powder.

**Physico-chemical Analysis**

Moisture content increased during storage in both 
CL and DL irrespective of packaging material and 
storage period. Compared to other packaging materials 
for CL and DL, when samples were stored at LT for 3 
months, gain in moisture content was low in 200 gauge 
HDPE, attributed to greater protection against water 
vapour infusion in HDPE. However, changes in 
moisture content within packaging material were 
non-significant. A similar finding was also reported in 
onion powder. With regard to storage condition, 
moisture content was less in samples stored at LT 
compared to RT. Difference in moisture content was 
found statistically significant, might be due to more 
permeability of LDPE film to water vapor compared to 
HDPE films. Sagar & Khurdiya also reported that 
moisture content increased very slightly during storage 
in dehydrated mango slices and powder.

With increase in storage period, β-carotene, 
chlorophyll and ascorbic acid content decreased 
gradually during 3 months of storage of CL (Table 2) 
and DL (Table 3). β-Carotene retention was better in 
dehydrated CL (4788 µg/100g) and DL (4658 µg/100g) 
when product was packed in 200 gauge HDPE and stored 
at LT (7±1°C). However, loss in β-carotene was 
significantly less among different packaging material. 
With regard to storage temperature, samples stored at 
LT retain more β-carotene as compared to RT. However, 
difference in β-carotene due to storage temperature was 
found statistically significant. Similar trend is reported in 
green leaves.

**Chlorophyll was higher in CL (116.25 mg/100g) and 
DL (65.25 mg/100g) when samples packed in 200 gauge 
LDPE pouches in CL and DL during 3 months of 
storage. In the same period, decrease in chlorophyll in 
CL and DL respectively was less at LT (112.0 mg/100g 
and 61.85 mg/100g) compared to RT (102.18 mg/100g 
and 55.95 mg/100g). Difference among packaging was 
statistically significant, might be due to prevention of
chlorophyllase activity and conversion of chlorophyll to pheophytin. Chlorophyll content was slightly better at LT than RT. However, difference in chlorophyll content due to storage temperature was found statistically significant. Similar results were observed in CL (Table 2) and DL (Table 3).

Ascorbic acid was higher in CL (196.43 mg/100g) and DL (143.30 mg/100g) after 3 months of storage when samples were packed in 200 gauge HDPE and stored at LT, might be due to better protection by packages due to less permeability of film as compared to other packaging materials, wherein ascorbic acid was less but reduction in ascorbic acid was statistically significant. Similar trend is reported in onion powder. Ascorbic acid content was higher in CL and DL stored under LT compared to RT (Tables 2 & 3), might be due to rapid degradation of ascorbic acid at higher temperature. Similar pattern has been reported in other dehydrated vegetables. Ascorbic acid content also decreased with increase in moisture content during storage, might be due to rapid increase in activity of ascorbic acid oxidation and other relevant oxidizing enzymes in dried and dehydrated leaves at higher moisture content in samples compared to others. Similar work is reported in dried onion flakes. However, difference in reduction on ascorbic acid was statistically significant.

**Non-Enzymatic Browning (NEB)**

NEB increased with increase in storage period at both temperatures in all packaging materials. NEB was less in dehydrated samples of CL and DL when products were packed in 200 gauge HDPE and stored at LT for 3 months, might be due to less moisture content in samples packed in 200 gauge HDPE pouches compared to others. Changes among packages were not found statistically significant. NEB was less in samples stored at LT as compare to RT, may be due to less moisture absorption at LT and reduced reaction between sugar and amide components of dried LV. Similar trend is reported in LV. Changes due to storage temperature were statistically significant (Tables 1 & 2).

**Rehydration Ratio (RR)**

RR was higher in CL (1:2.59) and DL (1:4.29) when products were packed in 200 gauge HDPE and stored at LT for 3 months, might be due to less absorption of moisture in HDPE film during storage. Similar result is reported in mango slices. Changes occurred due to packaging material and storage temperature were
non-significant (Tables 2 & 3). RR was less at RT in all packages. However, decrease in RR was less when product was stored at LT compared with RT.

**Sensory Analysis**

Sensory score made based on 5 point hedonic scale increased, irrespective of packaging material and storage temperature. Increase in score was due to poor texture, loss of flavour and poor in colour with prolonged storage. Best score was obtained to the product packed in 200 gauge HDPE and stored under LT for 3 month (Tables 2 & 3), might be due to less gas permeability of packaging material and reduced physiological activity of product under LT. Higher score was obtained when product was packed in 200 gauge LDPE for CL (3.33) and for DL (4.33) at LT storage for 3 months. Increase in sensory score in respective of packaging material for DL was found statistically significant but for CL it was non-significant. However, changes in sensory score in respective of storage temperature were found statistically significant for CL and it was non-significant for DL.

**Conclusions**

Dehydrated LV have great potential to use throughout the year for preparation of several types of mix vegetables after rehydration even during off-season. Drying of LV and making them use for future open up new vistas in the field of food technology as curry mix and other condiments. Dehydrated LV are rich in antioxidants and could be added as natural antioxidants to develop new commercial products. Developing new packaging and storage techniques are essential to extend their shelf life without much deterioration.

**References**